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THE COINAGE OF THE GREEKS.

By G. F. HILL, M.A.

BY a coin is usually understood a piece of precious metal (as a rule gold, silver, or copper) of a size and shape convenient for handling, and marked with some stamp to guarantee its genuineness and save the trouble of continually calculating its value. In the days before the invention of money, exchange had been carried on by a process of barter, so much of an article offered being exchanged against so much of an article required. But it was naturally found convenient to agree upon a medium having some intrinsic value, and not liable to excessive fluctuations, which would always be desirable, and would, therefore, be accepted at all times by all parties. As early as the seventh century before Christ in Asia Minor, and, perhaps, even earlier in the far East, it was found that the most practicable medium was a precious metal divisible into small quantities, each of which would be equivalent in worth to comparatively large quantities of other articles of commerce. In earlier times we find various other things, more or less clumsy, employed as measures of value. For instance, over a great part of the world, the unit in terms of which other articles were valued was the ox. A less bulky unit is the cowry-shell, used even at the present day in some parts of Africa, where the employment of metal for this purpose is impossible or has not been thought of. The traces of such customs long remained, being, perhaps, most marked in the conservative Chinese Empire, where pieces of metal in the shape of small knives or spades long continued to circulate, or in Burma, where coins are still cast in imitation of shells.

Coinage then, properly speaking, begins with the use of small pellets or lumps of metal of fixed weight; and that these may be plainly stamped, they have to be of a somewhat flattened form. This is the shape of the earliest coins of Greece or Asia Minor which have come down to us. The blank of metal, being placed (often in a heated state) on an anvil, was struck with a stamp. A design let into the anvil left its impression on the lower side of the blank (generally called the *obverse*), while the upper (or *reverse*) side was marked by the stamp. The latter instrument was at first left undecorated (Fig. 1), but was afterwards elaborated until the reverse design became nearly as important as the obverse. The ancients seem to have always used bronze for their dies, and as this soft material easily wore out, the dies had constantly to be recut. The result was an enormous variety in design, and it is rare to find two ancient coins from the same die. Neither did they use a collar to confine the metal, which, consequently, was liable to spread irregularly in the striking, sometimes to splitting-point. And the fact that the striking was done by hand accounts for the frequent occurrence of what are called double-struck coins, when the second blow brought the stamp down in a different place from the first, or the coin had shifted between whiles on the anvil.

The fabric of Greek coins went through a steady process of development. The earliest blanks were of a somewhat dumpy oval shape—in fact, resembling a bean in form. But by the beginning of the fifth century a flatter and rounder shape had become almost universal. The impression made by the stamp, the head of which was square or oblong, or a combination of two or more of these shapes (see Fig. 1), now sank deep into the blank, and a raised border was thus left round the design. With time the depth of the *incuse* decreased, and towards the end of the fifth century we find the incuse square often replaced by an incuse circle, or entirely disappearing. After about 390 B.C. it may be said to be almost entirely absent, save when for some reason a few cities revived it on their issues at a much later period. The stamp, however, which was now generally circular, naturally continued to produce a more or less concave field on the reverse of the piece. In the third and second centuries the flattening and spreading of the coins was carried still further, but never so far as to destroy the strength and solidity of fabric which makes a coin satisfactory to handle. The bronze coinage which begins in the fourth century is, like the silver of earlier times, thick and dumpy at first, but soon yields to the general tendency and becomes flat and spread.

It is curious that the material used by the people to whom the invention of money is attributed—the Lydians, a wealthy and powerful race of Asia Minor—is neither gold nor silver, but a mixture of the two. This mixture, which is called electrum, was found in a natural state in the district inhabited by them, and its adoption is therefore easily understood. Its value in relation to silver was supposed to be about ten to one, while the proportional value of gold to silver was in the less convenient ratio of $13\frac{1}{3}:1$. As a matter of fact, modern analysis has proved that the amount of gold in electrum coins varies very considerably; but a rough proportion was probably sufficient for the times. Electrum, however, was not

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found everywhere, and in the sixth century gold and silver came into use—a change associated with the proverbial name of Crœsus the Lydian. The Greek cities of the Asiatic coast and in Europe readily adopted the invention of the Lydians, but the scarcity of gold in Europe almost entirely limited the coinage of European Greece to silver. Thus, while some of the Greek cities of Asia Minor continued to coin electrum, silver was the metal employed in the other cities of that continent and in Europe. Gold was a monopoly of Persia until the end of the fifth century. Although the ancients understood the art of debasing and plating, the purity of their coinage in these early times is remarkable. As to the other metals, a very short notice must suffice. We hear of iron coins in Sparta, and tin coins at one period in Syracuse; but none of these have come down to us. Bronze was introduced in the fourth century, and remained the usual metal for the smaller denominations. The increasing wealth of the Greek cities now enabled them to issue gold, and Philip II of Macedon (359-336 B.C.) and his son, Alexander the Great (336-323 B.C.), struck enormous quantities of gold as well as silver coins. One other metal, it is interesting to note, was used in the second century by a few of the kings of the remote district of Bactria (corresponding to south-western Turkestan), to which the ambition of Alexander had carried the arms and civilization of Greece. This was an alloy of copper and nickel, in almost the same proportions as are employed by several modern states. The discovery of "kupfernickel" in the eighteenth century was thus anticipated by some two thousand years.

The unit of coinage was called the *stater*. As different cities coined on different standards, this varied considerably in weight. The question of standards, far from settled as it is, cannot be discussed here. It must suffice to mention, with regard to denominations, that the stater was divided into two (exceptionally three) *drachms*, and the drachm into six *obols*. Larger denominations were the di-stater or tetradrachm, the octadrachm, and the decadrachm, of four, eight, and ten drachms respectively.

Tradition attributes the first striking of coins in Greece proper to Pheidon, King of Argos; but what he actually did in this direction is a subject of much dispute. We may, however, be certain that coinage was first adopted in Greece about the end of the seventh century. From Greece proper, with the colonization of Italy and Sicily, the art of coinage spread to the western Mediterranean in the middle of the sixth century. The earliest Italian coinage is of a peculiar fabric, the reverse design being the same, or nearly the same, as the obverse, but represented in intaglio (*incuse*) instead of in relief (Figs. 3 and 4). In Sicily no such peculiarity is found.

The fifth century witnessed the transition from archaism to artistic perfection, from the stage in which the artist produced a sometimes grotesque but always honest attempt to represent his object, to that in which he obtained perfect mastery over his material and tools. Owing to the disappearance of the incuse square or circle, both sides of the coin became flat, and the design on both stood out nearly equally in high relief—a relief much too high from the modern point of view, according to which, coins should be flat and easily packed together. But to the height of the relief is due much of the effect of ancient coins, which present us, in fact, with a sculptured design, not a flat outlined pattern.

Although most states obeyed the general tendency, and produced better executed work as time went on and skill increased, it is noticeable that some of the greatest commercial cities adhered to certain archaisms of style or fabric, probably because the scope of their commercial relations forbade any innovations which might damage the genuine appearance of their money in the eyes of the less civilized peoples with whom they traded. Thus the coins of Athens (Fig. 6), the chief centre of Greek art, are rude to excess in comparison with the contemporary productions of other cities (Fig. 12). And the important city of Cyzicus, on the present Sea of Marmora, continued down to the middle of the fourth century to put no design on the reverses of its numerous electrum staters, the obverses of which were, nevertheless, executed in the best style (Fig. 14).

By the fourth century, the art of coinage had reached its highest point. Nothing is more generally admired than the famous "medallions" of Syracuse, struck in the late fifth and early fourth centuries. These large decadrachms, of which we give an example (Fig. 8), are perhaps the most showy pieces of antiquity—indeed, it is doubtful whether they circulated as ordinary coins, and were not rather show pieces, or money struck for prizes. The chariot and four, and the prize set of arms—helmet, cuirass, shield, and greaves,—represented in the *exergue*, seem to bear out this latter opinion. The games to which the type obviously refers may have been those instituted by the Syracusans in the flush of their victory over the Athenians on the Assinaros in B.C. 413. The main design, however, had been anticipated more than sixty years before, on a coin to which we shall have to refer on a later occasion. Many of these medallions bear the names of the artists who designed them—Kimon and Euainetos—names which would otherwise have been totally forgotten, though their work takes an easy place in the first rank. Fine as these coins of Syracuse are, they are still only typical of a great number of equally beautiful pieces struck, not only in Sicily and South Italy (Figs. 9 and 10), but in widely distant places such as Elis (Fig. 12) and Amphipolis in Macedonia (Fig. 13).

The coins of the best period are successful because they combine nobleness and simplicity of conception with perfect execution. But from this time onwards the latter quality becomes ascendant, and as skill of hand is powerless to produce good work unless the mind supplies good ideas, towards the end of the fourth century the decline of art in coins, as in all else, has thoroughly set in. The influence of Philip and Alexander of Macedon was decisive, not only in politics, but in all forms of human activity; and the personal element which they introduced became dominant in art. The designs of coins had hitherto, as a rule, been connected with subjects relating to the state as a whole, its religion, its athletics or its commerce; the successors of Alexander used the royal prerogative of coinage to commemorate themselves and their own interests. Hence the beginning of portraiture. Philip and Alexander themselves had adhered to religious or athletic types (Figs. 15—18); but the head of Heracles on the latter's coins (Fig. 18) was only an idealized representation of Alexander conceived as Heracles. And his successors, going a step further, put the portraits, first of Alexander, with some divine attribute (Fig. 19), and then of themselves with similar attributes (Fig. 20) or as human rulers, where formerly only the gods, or at least impersonal subjects of state-importance, had been seen. The name of the ruler, with the epithet "king," also replaced the name of the people, and the place of mintage was indicated, if at all, only by a small symbol or initial letters in the field of the coin. The imagination which characterized the earlier designs is replaced by a realism which, it is true, produces most marvellous representations of individual men, but which is, nevertheless, equalled by the art of other countries,

while the art of Greek coinage in the preceding period stands unapproached. Some of the most striking of these portraits were, strange to say, produced in the distant land of Bactria, to which we have already referred (Fig. 22).

But the vast mass of Greek coinage from the third century ceases to possess an interest anywhere approaching that of earlier days. The types become formalized and stereotyped. The great issues of Philip and Alexander (from the gold coins of the former our own early British coins were by a slow process of degeneration developed) remained for some time the chief currency of the ancient world. Next to them for importance rank the issues of Lysimachus, King of Thrace, of Athens and Rhodes, and of the Kings of Syria, Pergamus and Egypt. But all alike are less interesting to the artist than to the minute historian who studies the sequence of rulers and monetary magistrates. The work is usually poor and hastily executed; in fact the pieces have almost ceased to be works of art, and are mechanically reproduced. In time the influence of Rome begins to be felt, to the destruction of whatever artistic purpose lingers still. The Roman rulers struck coins (Fig. 21) in the Asiatic provinces which bore, it is true, a type relating to a religious subject (the *cista* or chest connected with the mystic worship of the wine-god Dionysos, from which the coins were called *cistophori*), but the coins were no longer closely associated with the life of a particular city which issued them. It was the lively interest of the Greek in the affairs of his own city which had enabled him to produce the finest art. In the universal empire of Rome the individual Greek could have no part, and the intellectual, as well as the political, centre of the world was now shifted to the banks of the Tiber.

In this brief sketch of the coinage of Greece we have dwelt mainly on the external form which that coinage assumed. There is one question, however, which we must not be content to pass over with a mere allusion, and that is the actual significance of the types before the period in which, as we have seen, the influence of the ruler became supreme. Before the introduction of money, types bearing some resemblance to those afterwards found on coins occur on the engraved gems which were used to set the seal of ownership on articles of value. Now the state, in issuing coinage, would wish to mark it with some stamp representative of itself and its right to make such issues; and as the Greeks were an essentially religious people, it was natural that they should regard the chief deity of a city as its representative. Hence it is that a very large proportion of coin-types have a religious significance. The human figure or face is, however, the last thing in the delineation of which art attains mastery, and consequently the early artists were content to represent god or goddess by some symbol or attribute, rather than in person. A stag represents the huntress Artemis; a thunderbolt Zeus, the god of the sky; a lyre or a tripod (Fig. 3) Apollo, the god of music and prophecy. But this is far from exhausting the nature of coin-types. Those natural objects which were especially characteristic of a place and its surroundings would, of course, suggest themselves; a maritime city, whose chief interest was fishing or seafaring, would engrave on its money perhaps a ship, perhaps a dolphin, a sea-shell, or a cuttle-fish. Lions, goats, or boars (Fig. 5), would figure where these animals were plentiful. The wild celery grows in such large quantities near Selinus, in Sicily, as to give its name to the town, and its leaf figures on the coins, just as does the fig-leaf on the coins of Camirus in Rhodes. The particular article of commerce for which a city was famous might be suggested by its coin-type; thus we find trade in wine represented by a wine-jar or wine-cup. Silphium (*Ferula tingitana* or, perhaps, *Thapsia gummifera*) was a plant much cultivated on the Barca plateau, and, therefore, was the almost constant type of the coins of this district of Northern Africa. Some coins of Barca bear the silphium plant with a gazelle couched before it or browsing on its shoots. On another (Fig. 11) the silphium is seen from above, and in the field are a jerboa, a chameleon, and an owl. Another little piece of local colour is found at Metapontum, in South Italy, where, on one coin the "praying mantis" (*Mantis religiosa*) is seen perched on a leaf beside the main type (an ear of corn, *cp.* Fig. 4). Much has been written to prove that all types are in their origin commercial, and that, for instance, the occurrence of a boar denotes a special line in hams. Neither this view, nor the view that all types have a religious significance, expresses the whole truth. The fact is, that a city famous for its wine would naturally regard the wine-god as its chief deity, and, therefore, represent him, or something connected with him, on its medium of exchange. The proof of this is that as soon as the Greeks became able to represent the deity in question satisfactorily, the article of commerce over the production of which that deity presided occupied, as a rule, a subordinate position on the coins. Athens was famous for its olives, which were under the protection of Athena; and on the later coins the head of Athena occupies the obverse or more important side, while the reverse bears the owl (symbolic of Athena's wisdom), the olive-wreath, and the jar of olive-oil (Fig. 23.) A city situated on a river of importance often adopted as type the representation of the river-god (conceived as a bull—significant of the stream's tumult and force—or a monster with the body of a bull and the head of a man, or again, a horned man). Still, many a coin-type remains less than half explained. Why have we on the coins of Lampsacus, in Mysia, a combination of two heads, looking different ways, on a single neck? Why a cock on the coins of Himera, in Sicily? It may be connected with Asclepios, the physician-god, for there were healing-springs in the neighbourhood; or, though this is less probable, the "bird of day" may be a punning allusion to the city-name, which only differs slightly from the Greek word for day (*hemera*). The use of punning types was by no means uncommon. Thus, on coins of Phocæa, in Asia Minor, we have (Fig. 2) the seal (*phoke*); on coins of Rhodes, a rose (*rhodon*). Other types, again, allude to some event connected with the history of a city; thus, on some coins of Thebes, an infant Heracles, strangling the snakes which attacked him in his cradle, symbolizes the struggle with the old-established power of Sparta, in which Thebes (where Heracles was worshipped) was victorious. Or the victory won at the Olympian games by the ruler of some Sicilian town would be commemorated by a chariot drawn by horses, on the heads of which, or on the head of the charioteer who guides them, the goddess of Victory places a wreath. One of the most remarkable of Greek coins (Fig. 7) was struck just after, and may allude to, the great victory of the Greeks over the Carthaginians at Himera in the same year (480 B.C.) in which the Persians were defeated at Salamis. On the reverse is a female head (perhaps that of the goddess of Victory herself) wreathed with laurel, and surrounded by the name of the people (the Syracusans). Around swim four dolphins, expressing, with a symbolism characteristic of the time, the fact that the sea surrounds the island of Ortygia, which is the centre of Syracuse, and which the goddess represented has under her protection.

But the discussion of the types of Greek coins might be prolonged indefinitely. For further information on this and the other matters with which we have dealt so slightly,

but it is hoped suggestively, the student must be referred to books like Head's "Historia Numorum" and Gardner's "Types of Greek Coins," illustrated works which cover in a scientific way the vast field of Greek numismatics. The subject is one in which the student of the history of the ancients, their politics, commerce, art and religion, should be thoroughly grounded before he can pretend to understand the facts, often distorted by literary tradition, about the life of a people from whom we have not a little to learn, and who, at least, will always remain interesting for their own sake.

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COLOUR-PRODUCING BACTERIA.

By C. A. MITCHELL, B.A.Oxon.

ALTHOUGH the bacteria belong to the vegetable kingdom, the colouring matter known as *chlorophyll*, to which plants owe their green colour, has not been found in them. They may, in fact, be looked upon as low forms of plant life minus *chlorophyll*. Many of them, however, have the power of producing other colouring matters, some of which are strikingly beautiful, and to these micro-organisms the name of *chromogenic* bacteria has been applied. They are widely distributed in water, soil, and air, as may readily be proved in the case of the last by leaving moistened bread exposed to the atmosphere for some days, when, in addition to the moulds which form upon it, there will be noticed coloured patches here and there, which, by microscopic examination, will prove to be colonies of micro-organisms. In Prof. Frankland's recent publication* a long list of the micro-organisms which have hitherto been found in water is given, and of these at least seventy species give rise to a distinct colour on cultivation.

To give anything approaching a complete list of the chromogenic bacteria would be little more than a tedious catalogue of names, and it is, therefore, preferable to select a few typical instances for detailed examination, from which a general idea of the remainder may be gathered.

Several species are capable of elaborating a red colouring matter, and the coloured substance produced by one variety differs in properties from that produced by another. All shades of red have been observed, from faint pink to bright vermilion and deep blood-red.

The *pink Torula*, an organism allied to the yeasts, is frequently met with in the air, and forms a rose-tinted scum when grown on bread paste. It has large round or ovoid cells, 5μ—8μ† in diameter, which, unlike those of true bacteria, are capable of multiplying by budding. The pink colour is only apparent in the mass, for, under the microscope, individual cells appear to contain a yellowish pigment.

Another well-known chromogenic organism is *Bacillus prodigiosus*, which is frequently found in the air, and is the cause of the phenomenon, which has occurred at various times, of bread or grain assuming a blood-red colour. This is the probable explanation of the miracles and portents of the sort which were once firmly believed in. The micro-organism was formerly described as a micrococcus, since it is almost as broad as long, but it is now usually classed among the bacilli. It is about $1{\cdot}5\mu$ in length by 1μ in breadth, and two or more individuals may occasionally be noticed hanging together in chains. On whatever medium grown, the pigment produced is the same, and the colony usually appears as a rich crimson layer on the surface of the cultivation.

The bacillus is generally stated to be non-pathogenic, but it has been shown by Grawitz and De Bary that the introduction of large quantities of the pure cultivation into the blood of animals sets up symptoms of inflammation.

The colouring matter is soluble in alcohol and ether, but insoluble in water. With dilute acids it becomes light red, but the original colour is restored on adding an alkali. It appears to be closely connected, though not identical, with the aniline colour *fuchsine*.

In 1888, Dr. Edington published a paper on the nature of "red" cod. In the previous year a large consignment of the dried and salted fish had arrived at Lerwick, having on their inner surface, and especially among the particles of salt adhering to them, minute red points which resembled little particles of vermilion. On investigation it was found that, although several species of bacteria could be isolated, the one which produced the red coloration was a bacillus, to which its discoverer gave the name of *B. rubescens*. When grown on nutrient jelly, a wrinkled colony was formed, in which the pink colour only developed after some weeks. The bacillus was found not only in the fish, but also on the salt used by the curers, showing that salt is not so strong a preservative as is often supposed. Though the organism was proved to be in itself harmless, the fact of its being present at all showed that the fish were insufficiently preserved, and might thus readily become a culture medium for pathogenic species.

A peach-coloured organism, *Beggiatoa roseo-persicina*, was discovered in 1873 by Prof. Lankester, in water containing dead animal matter. During its life-history it passes through several forms, the most characteristic of which is a long spiral. It is usually the cause of the blood-red films which may sometimes be observed in pools and marshes.

* "Micro-organisms in Water," by Percy and G. C. Frankland, 1894.

† 1 $\mu = \frac{1}{25000}$ of an inch.

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GREEK COINS

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Among the bacteria producing a blue colour on cultivation, the bacillus of "blue milk," *B. cyanogenes*, is one of the most typical. It is not an uncommon occurrence, especially in parts of Germany, for milk, otherwise perfectly normal, to assume a bright blue colour; and before the real cause was known, many theories were put forward to account for the phenomenon. For instance, it was ascribed by various observers to iron, indigo, and a diseased condition of the cows; while Henri Bracconat thought it was due to spontaneous decomposition of the milk. The bacillus which is now known as the cause is a motile organism 3μ in length by $\cdot 4\mu$ in breadth. Grown in milk it produces a slate-blue colour, changing to bright blue as soon as the milk commences to turn sour. No coloration occurs if the temperature be above 36° C. According to Erdmann the colouring matter is the same as the aniline colour *tri-phenyl-rosaniline*, but this is denied by Schröter. In its physiological effect "blue milk" appears to be harmless, and chickens have been fed for weeks on bread soaked in it without being any the worse.

The bacterium of "yellow milk," *B. xanthinum*, is an interesting illustration of an organism producing a yellow pigment. In boiled milk it gives rise to a bright yellow coloration, which it also shows when grown on sterilized potato. The colouring substance, which is very similar to the yellow aniline colours, is soluble in water, but insoluble in alcohol. The organism usually occurs in the form of *cocci*, about 1μ in diameter. Green pigments are produced by several species of bacteria, more than half a dozen of which have been found in water. Of these, *Bacillus fluorescens liquefaciens* occurs most frequently. It is of a short rod form, $1{\cdot}5\mu$ long and $0{\cdot}5\mu$ broad. When grown on gelatine it causes the culture medium to assume a beautiful fluorescent green colour, and at the same time liquefies it.

Representatives of the other colours—violet, orange, and brown—may also be found among those formed by bacteria. According to Cohn and Schröter, who attempted to classify them by their solubility in water, the red and yellow substances are, broadly speaking, more soluble in that liquid than the orange, green, and blue. In some cases the colour is confined to the protoplasm and intercellular substance of the bacteria, while in others (*e.g.*, the "blue milk" bacillus) it spreads outside the cells on to the culture medium. It would thus appear that some are products of excretion, as well as of secretion, and all seem to be formed through the decomposition of the nitrogenous substance in which they grow. As to the part they play in the physiology of the bacteria but little is known, and the suggestion that they supply the place of *chlorophyll* in plants does not throw much light on the question, since it has not yet been proved beyond doubt what the function of chlorophyll is.

THE GIANT BIRDS OF SOUTH AMERICA.

By R. LYDEKKER, B.A.Cantab., F.R.S.

FOR many years the minds of philosophical ornithologists have been much exercised by the problem of the origin and phylogeny of the existing flightless ostrich-like birds and their fossil relatives. Not very long ago, we believe it was not an uncommon opinion that all these Ratite birds, as ostriches, rheas, cassowaries, and emeus are collectively called, were the immediate descendants of a certain group of extinct reptiles, and that they themselves gave origin to the flying birds. One circumstance is, however, fatal to this hypothesis. As most of our readers are probably aware, flying birds have the bones of the fore-limb, or wing, constructed on a very peculiar plan, and quite unlike those of either mammals or reptiles. But precisely the same type of structure is presented by the rudimentary wings of such of the ostrich-like birds as possess these appendages at all; and it is quite clear that if these birds had been evolved from reptiles in the condition we now find them—that is to say, without the power of flight—they would have retained the reptilian type of fore-limb, and would not have an aborted bird's wing. Hence it is clear that we must regard the ostriches and their allies as the descendants of birds endowed with the power of flight, but whose wings have become gradually atrophied by disuse till, as in the emeus, they are extremely minute, or, as in the extinct moas of New Zealand, have even completely disappeared. Having arrived at this satisfactory conclusion, the reader might perhaps think that there was nothing more to be said on the subject; but here, unfortunately for his peace of mind, another problem presents itself for consideration. We have, indeed, to decide whether all the Ratite birds have sprung from an original flying ancestral stock, or whether several flying birds have given rise to degraded flightless types which have subsequently become so like one another as to form one apparently homogeneous group.

So far as the existing and later Tertiary representatives of these giant flightless birds are concerned, it does not appear that we have at present any means of deciding this question one way or the other. The discoveries made during the last few years in the older Tertiary deposits of Patagonia have, however, gradually brought to light the remains of a group of most extraordinary gigantic flightless birds which formerly inhabited that country, and which are so totally unlike all the modern Ratitæ, that there can be no reasonable doubt as to their having originated independently from flying forms. When we have once admitted the independent origin of one group of giant flightless birds, there appear at first sight no great reasons why the modern types should not have had a diverging ancestry, although, as we shall see later on, there are certain grounds for regarding them as derived from a single stock.

FIG. 1.—Lower Jaw of *Phororhachis longissima*. About one-seventh natural size.

For a knowledge of the giant flightless birds of Patagonia we are mainly indebted to the labours of Señor Florentino Ameghino, of Buenos Ayres, from whose latest work on this subject the accompanying illustrations have been copied. The first example of their remains brought to light was a portion of a lower jaw, and so massive and unbird-like was this bone that it was at first described as belonging to a gigantic edentate mammal. And no wonder either, for we have not hitherto been accustomed to deal with birds whose lower jaw measures about twenty-one inches in total length, as does the specimen represented in our first illustration. Indeed, it is even now difficult to convince English naturalists that the fossilized extremities of the beaks of these extraordinary birds are avian at all. At the end of 1893 I brought home such a

specimen, for the purpose of having a plaster-cast made at the Natural History Museum, and I had the greatest difficulty in making some of the authorities there believe that the specimen belonged to a bird at all—indeed, I am not sure but that I was considered to have made a hopeless blunder, and to have mistaken the claw of a ground-sloth for the beak of a bird. Be this as it may, the specimens which Señor Ameghino has now figured show the entire skull, so that whatever scepticism there may have been on the matter must now disappear.

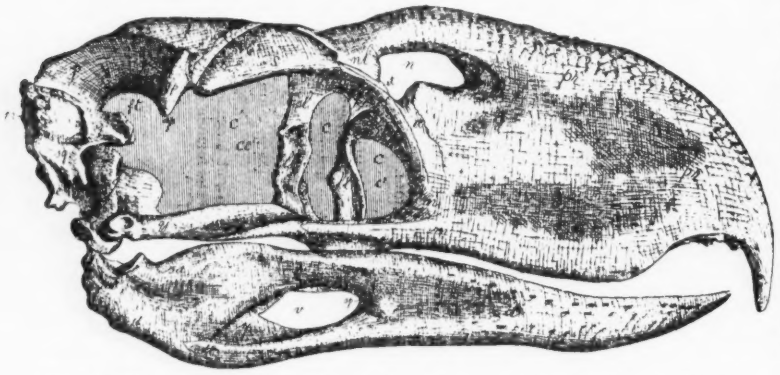


Fig. 2.—Side view of Skull of *Phororhachis inflata*. About two-fifths natural size.

Considering first the skull of the Stereornithes, as these birds have been called, this is remarkable not only for its excessively large size and massiveness, but likewise for its peculiar conformation, which is quite unlike that of any other group, either living or extinct. As shown in Fig. 2, the upper mandible of the beak is of great vertical depth, and very much compressed from side to side (Fig. 3), with its extremity forming a sharp hook. In common with many existing birds, the cavities for the eyes (Fig. 2, *cc*) are in free communication, owing to the absence of a partition of bone between them; and these cavities likewise are completely continuous with the preorbital vacuity (*c'*), a feature which Señor Ameghino states is unparalleled among existing birds. The nostrils (*n*), which likewise have no dividing septum, are situated high up in the compressed beak, only slightly below the level of the upper surface of the hinder part of the skull. A feature in which the Stereornithes differ from all living Ratitæ, and hereby resemble the flying birds, is to be found in the presence of two distinct condyles or heads, by which the quadrate bone (*q*) articulates to the skull proper. The lower jaw which is abruptly truncated at its hinder extremity, has a large lateral vacuity, and its pointed tip curves slightly upwards; the symphysis, or union between its two branches, being long and trough-like. Apparently the only living birds in which the extremity of the lower mandible is curved upwards are the South American trumpeters, *Psophia*.

Comparing this extraordinary skull with those of recent birds, one cannot help being struck with a superficial resemblance between the deep and compressed upper mandible with that of the puffins; but in those birds the conformation of the hinder extremity of the skull is totally different, while the large nostrils are pierced low down in the sides of the beak. In the hooked extremity of the upper mandible, and also in the narrowness of the whole of this region, there is a decided resemblance to the cormorant and the albatross, although in both those birds the beak is of no great depth, while the preorbital vacuity is sharply separated from the cavity of the eye. All three agree, however, in the truncation of the hinder end of the lower mandible, while the albatross has a vacuity in the side of the latter, and also no septum between the nostrils. On the other hand, while the upper surface of the skull of the albatross is quite unlike that of the fossil, there is a decided resemblance in this respect in the case of the cormorant, this being especially shown in the projecting processes at the postero-lateral angles. Whether this resemblance indicates any real affinity, I am quite unprepared to say, but it may be mentioned that both in the albatross and the cormorant the extremity of the lower mandible slopes downwards instead of upwards, while in the latter the symphysis is very short. The American vultures also resemble the fossils in their hooked upper mandible and absence of a nasal septum, but differ markedly as regards the rest of the skull. Unfortunately, we have no knowledge of the structure of the palate of the Stereornithes.

We have likewise no information as to the breast-bone or sternum of the latter, and we cannot, therefore, say whether it resembled the Ratite type in being smooth and flat, or whether it carried the prominent keel of ordinary flying birds. We do, however, know that the coracoid bones were of the narrow elongated type characteristic of the latter; while we have likewise information to the effect that the wings were comparatively well-developed, although incapable of supporting these enormous birds in flight. Perhaps they were used to aid in running, as are those of the modern ostrich.

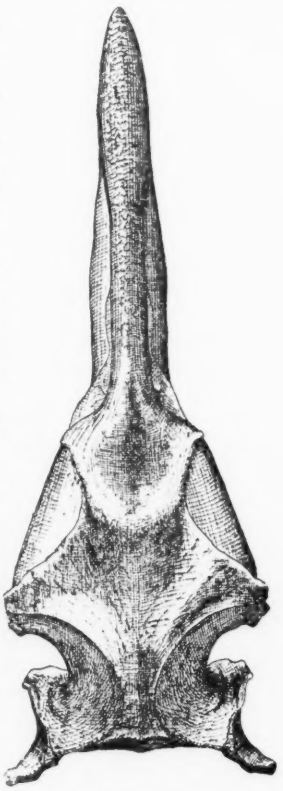


Fig. 3.—Upper view of the Skull represented in Fig. 2.

As regards the leg-bones, these indicate two very distinct generic types, the more slender of which (Fig. 4) accords in relative size with the relatively slender lower mandible of the typical *Phororhachis*: while a larger, stouter, and relatively shorter type (Fig. 5) agrees with a larger, shorter, more upturned and massive kind of mandible. To this second genus the name *Brontornis* has been assigned.

In the tibia of both genera, of neither of which we have figured an example, the lower end has a bridge over its front surface to hold down the extensor tendons; such a bridge being absent in all the existing Ratite birds, but present in the extinct moas of New Zealand, as well as in a gigantic bird from

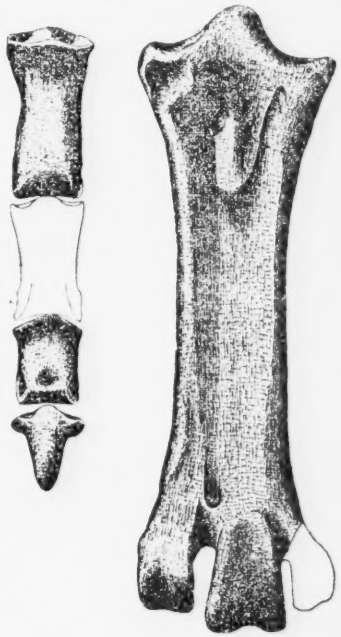
the lower Eocene of England and France known as *Gastornis*. In *Brontornis* this bone measures thirty inches in length, and in *Phororhachis* about fifteen and a half inches. In the latter genus the tarso-metatarsus (Fig. 4) has a total length of about twelve inches; while that of the former (Fig. 5) measures sixteen and a half inches. In most cases, as shown in Fig. 4, *d*, the first toe was present, but this is stated to have been wanting in some forms. A further difference between the two genera is to be found in the form of the terminal joint of the toes; in *Brontornis* (Fig. 5, B) this bone having a marked lateral expansion at its upper end, whereas in *Phororhachis* it tapers gradually from one extremity to the other. While the vertebræ exhibit well-developed pneumatic cavities, the leg-bones would appear to have been filled with marrow, like those of the modern Ratitæ.

FIG. 4.—Left tarso-metatarsus of *Phororachis*. *a*, from in front; *b*, upper end; *c*, *d*, back view of upper and lower ends; *e*, inferior extremity. About two-fifths natural size.

After a careful description of all the known remains of these gigantic birds, Señor Ameghino comes to the conclusion that while they cannot be placed among the Ratitæ, as now defined, neither can they well be included among the flying birds, or Carinatæ, as they agree with no living members of that group. With this conclusion I agree entirely. In respect to the structure of their quadrate-bone the Stereornithes are clearly more closely allied to the Carinatæ than are any of the modern or later Tertiary Ratitæ; but from the extraordinary structure and great relative size of their skulls, it is practically certain that they cannot be regarded as ancestral types of the latter, in all of which (with the exception of the New Zealand kiwis, where the bill has undergone a special elongation) the skulls are unusually small.

It is accordingly evident that the Stereornithes and the Ratitæ have originated, quite independently of one another, from flying birds; and this might lead to the conclusion that the latter have likewise had a multiple origin, and that the different family groups into which they are divided have no real relationship with one another. Without denying that this may be the case, it must be remembered that all the modern Ratitæ, together with the moas, agree with one another in having but a single upper articular head to the quadrate-bone, and likewise in the short and squared coracoid, as well as in certain other features. And as the first of these peculiarities is not an adaptive one, this at least is scarcely likely to have been evolved in all cases if the different families of that group had originated independently of one another.

The Patagonian beds from which the remains of the Stereornithes are obtained have been generally assigned by the South American palæontologists to the lower Eocene division of the Tertiary era; but this date is certainly too early, and they are more probably of Miocene or Oligocene age. Admitting this, the question then arises whether there are any older Tertiary birds which can be regarded as related to the Patagonian forms; and we naturally turn to the Eocene *Gastornis*, already mentioned, allied to which is another bird from the same European strata, known as *Dasornis*, and a third from the equivalent strata of North America, to which the name *Diatryma* has been applied. Unfortunately, we know the skulls of these birds only by fragments, but they appear to have been of relatively large size, although such restorations as have been given make them much more depressed than those of the Stereornithes. This, however, might be a feature of not more than family value. There are, however, other differences of considerably more importance, one of these being the circumstance that the component bones of the skull remained separate throughout life, instead of uniting at a very early period as in all existing birds; while another is to be found in the shortness of the bony union between the two branches of the lower mandible. It has also been considered not improbable that the upper jaw of *Gastornis* was furnished with a pair of large teeth; and if this should prove to be well founded, it will be evident that the group must have branched off from flying birds at a time when the latter were still toothed. Apart from this, although there appears to be no evidence as to the form of the head of the quadrate-bone, the tibia of these Eocene birds agrees with that of the Stereornithes, and the fragments of the coracoid indicate that that bone was of the same elongated type. As the extinct Patagonian Ungulates show remote indications of affinity with some of those of the early Tertiaries of Europe, it is accordingly not impossible that there may be a somewhat similar relationship between the Stereornithes on the one hand and *Gastornis* on the other. What the nature of this relationship (if such there be at all) may be, it is impossible at present to determine; but it may be considered pretty certain that neither the Stereornithes nor the *Gastornithidæ* can be henceforth included in the Ratitæ, and hence that that group is of comparatively modern origin.



B A

FIG. 5.—A, right tarso-metatarsus, and B, toe-bones of *Brontornis*. About one-fifth natural size.

In articles which have already appeared in KNOWLEDGE, it has been shown how widely different were the ancient Tertiary mammals of South America from those of all other parts of the world, and we have now evidence to show that the same was the case with the flightless birds. Although now, owing to the land-connection with the northern half of the New World, its fauna is less peculiar than it was in past epochs, yet it is still sufficiently distinguished to allow Tropical and South America to form one of the three primary zoological divisions of the globe.

THE COLOURS OF BUTTERFLIES.

By C. F. MARSHALL, M.D., B.Sc., F.R.C.S.

MOST people are familiar with the beautiful and varied colours met with among butterflies; but the reasons why such colours exist are, perhaps, not known to all readers of KNOWLEDGE, even in these post-Darwinian days. There are still, no doubt, persons who believe that the colours of insects, and other beautiful colours met with in nature, were intended for the special benefit of man, to please the eye of the "lord of creation." But any such idea is at once rendered absurd when we reflect that the most gorgeously coloured butterflies and birds are found in parts of the world where man does not dwell, and where he seldom ventures, viz., the tropical forests of South America and the islands of the Malay Archipelago.

The explanation of the colours of animals and plants is due chiefly to the investigations of Alfred Russel Wallace, and the results show that colour is no accidental quality, but that in several different ways it benefits its possessor in the struggle for existence. In the case of flowers, it has been shown that the colours and scent serve to attract insects to visit and fertilize them. Therefore, if insects can appreciate the colours of the various flowers, they must be able to distinguish colours in the members of their own and other species.

Let us now consider briefly the chief groups into which the colours of butterflies are divided, and the purpose served by each different kind of colouring.

1. *Protective Colours.*—These enable the butterfly to escape from its enemies, owing to the colouring bearing a strong resemblance to some other object, thus aiding concealment. The resemblance may be to another butterfly, or to a flower or leaf. Protective colouring is usually confined to the under surface of the wings, which is coloured more or less like the leaves or flowers on which the butterfly usually perches. When, as is their habit after alighting on their usual plants, the wings are folded up exposing the under surfaces only, the protective is often very striking. In some instances the resemblance is so strong as to deceive the most practised eye. One of the best known instances is that of *Kallima*, a butterfly met with in the Malay Archipelago. In this the upper surfaces of the wings are brightly coloured with orange and purple, but the under surfaces bear the most remarkable resemblance to the dead leaves of the plant on which it has the habit of alighting in its flight. Furthermore, in different specimens, resemblances may be found to dead leaves in almost every stage of decay. In other cases the resemblance involves the whole insect. *Phyllium*, the "leaf insect," resembles a group of leaves; here the joints of the limbs are flattened out and coloured like leaves, in addition to the wings. *Lonchodes*, the "stick insect," resembles a group of dried twigs.

Protective colours are not confined to the adult insect, but the larvæ are also often protectively coloured. The larvæ, or caterpillars of butterflies being soft-bodied, defenceless creatures, are in need of protection, and hence we find in them protective colouring. The usual colour of caterpillars is green, resembling the colour of the leaves on which they feed. Caterpillars which have the habit of feeding on grass are protected by longitudinal stripes which facilitate concealment. At the time when the larvæ are about to change into pupæ, or the chrysalis stage, they usually turn a brown colour to resemble the earth on to which they descend.

The common "stick caterpillar," found on ivy and other plants, is a good example of what is called "special protective resemblance." Anyone who has searched for these caterpillars will have experienced the difficulty there is in distinguishing them from the twigs of the plant on which they feed.

The explanation of protective colouring is offered by the theory of natural selection. No two butterflies are exactly alike, any more than any other two animals are exactly alike. The butterflies resemble other insects in being the food of birds, lizards, and other animals. Now, any butterfly whose markings and colour render it more like the leaves or other objects on which it perches, will have a better chance of being concealed, and so of escaping the enemies which prey on it. Such butterflies will, therefore, survive and transmit their peculiarities to their offspring. In these, again, some will have colours and markings of a greater protective value than their parents; these will survive, and in their turn will transmit their advantages to their descendants, and so on, generation after generation, the protective colouring becoming more and more marked till the extraordinary resemblances we have mentioned are reached.

2. *Warning Colours.*—These form a remarkable group of instances in which the colours are conspicuous, for the purpose of warning other insects to keep away. Warning colouring arises from the fact that if an animal, liable to be eaten by others, has a nauseous taste, it is advantageous that it should be quickly recognized, and hence avoided by the animals which would otherwise eat it as food. Some of the best known instances of warning colours are found in butterflies, especially some of those inhabiting the tropical regions. They are brightly coloured on both surfaces of the wings, and the colours are usually the same on both upper and under surfaces of the wings. They all excrete juices of a powerful odour which are offensive to insect-eating animals.

Warning colours are also frequently found among caterpillars, such as those of the common magpie moth, the cinnabar moth, and the tiger moth. These are all brightly coloured and take no pains to conceal themselves, and if offered to lizards, frogs, and other animals, will be rejected.

The origin of warning colours is also explained by natural selection, but on a different line to the explanation of the protective colours. In this case those accidentally possessing a nauseous taste will have a better chance of surviving in the struggle for existence. The peculiarity will be transmitted and increased in intensity from generation to generation in the same way as the protective resemblances are increased. In the case of the warning colours, the insect having the most nauseous taste and most gaudy colouring will survive.

3. *Sexual Colours.*—These are found when the two sexes differ considerably in colour. As a rule, the male is of the same hue as the female, but of a deeper and stronger colour. In other cases, as in the common orange tip butterfly, patches of colour are found in the male but not in the female. Darwin explained the more brilliant colours of the male as being due to what he termed "sexual selection"—*i.e.*, to the female having preference for a more brightly coloured male, thus giving rise by selection to the development and survival of the more brilliantly coloured males. On the other hand Wallace explained the more sober colours of the female as being protective in order to escape detection while laying eggs—a period during which there is more exposure to attacks from enemies, and so more need for protection.

4. *Mimicry.*—Many butterflies escape destruction by mimicking the colours and markings of the uneatable forms.

Cases of mimicry are really of the same class as protective colours, but would be incomprehensible but for our knowledge of warning colours. Insects possessing warning colours are, as we have seen, nauseous and unpalatable to the animals which pursue them as prey; they, therefore, advertise themselves by their bright colours so as to be easily recognized and so escape destruction. Hence it is plain that other edible insects, if they have colours and markings resembling those of the nauseous ones closely enough to be mistaken for them, may benefit by the resemblance, and escape.

A large number of these cases are now known in which an edible butterfly mimicks an inedible and nauseous one, protected by its warning colours, so closely, that in many cases they would be considered members of the same species. This resemblance may be so close as to deceive the butterflies themselves, and the male of the mimicking butterfly has been seen pursuing the female of the mimicked species, unaware of his mistake till he got very close to her.

The colours of animals and plants, of which those of butterflies are some of the most important, forms in fact one of the most interesting and delightful branches of natural history, and furnish us with many problems, with which the above remarks deal only too briefly.

Science Notes.

Dr. Deninger, of Dresden, has prepared carbon monosulphide CS pure for the first time, and finds that, instead of being as described in the text-books, an amorphous red solid, it is really a colourless gas. He prepared it by heating dry sulphide of sodium with chloroform, or, preferably, iodoform, in sealed tubes to 180° C. The gaseous products were made to bubble through aqueous caustic potash, which absorbed the sulphuretted hydrogen, and the carbon monosulphide passed through unabsorbed. By acting upon carbon disulphide with sodium, in the presence of some aniline, the new gas was also obtained. It is colourless, and easily condensable to a clear liquid, which, however, rapidly evaporates. It burns in air with a bluish flame to form CO_2 and SO_2. It is extremely explosive, and was only with some considerable difficulty analyzed and found to have a composition equal to CS.

M. Berthelot's experiments on the absorption of argon by benzene are very interesting, and exhibit argon in a new light. The fact that the greenish-yellow phosphorescence of this mixture is very like that of the aurora borealis indicates a probable explanation of this hitherto unexplained natural phenomenon.

Some years ago the Dutch chemist, Lobry de Bruyn, isolated pure anhydrous hydroxylamine by a somewhat peculiar reaction, and the happy idea recently struck him of applying the same process to the isolation of hydrazine N_2H_4. Hydrazine has never been obtained free from water, but always as the hydrate $N_2H_4 . H_2O$; indeed, so strong was this attraction for water that its discoverer Curtius recently asserted that its isolation was, he felt convinced, impossible, though he thought the gas N_2H_4 might in some cases be momentarily liberated. However, de Bruyn, by acting on sodium methylate with hydrazine hydrochloride in methyl alcohol and then fractionally distilling the products, obtained pure hydrazine as a colourless *liquid* of fairly high boiling point and freezing at 4° C. It is really very stable, but hisses with water and, of course, fumes vigorously in moist air. The halogens all react violently with it, as also does sulphur.

In a recent number of the *American Chemical Journal*, there is an interesting paper by H. N. Stokes on some nitro-chlorides of phosphorus. Dr. Gladstone, some years ago, by the action of pentachloride of phosphorus on ammonium chloride obtained the substance $(PNCl_2)_3$. Stokes has by the same process obtained also the corresponding acid $(PN(OH)_2)_3$. This substance $(PNCl_2)_3$ crystallizes in enormous crystals of unlimited size, and exhibits a remarkable repugnance to being wetted by water, upon which the crystals consequently float. They have a pleasant odour, but after some time the odour produces a very painful difficulty in breathing.

For many years the actual existence of the original manuscript of the "Natural History of Selborne" was known to but a few people. At the death of Gilbert White it had remained with Benjamin White, his brother, the publisher of the original edition of 1789. From him it descended to his son Benjamin, who in turn passed it on to his son, the Rev. Glyd White. The Rev. Glyd White bequeathed it to Mr. A. Holte White, on the dispersal of whose estate it for the first time reached the auction room on Friday, April 26th, 1895. Messrs. Sotheby, the auctioneers, had been unable even to suggest its value, and it had been considered beforehand whether it would be well to dispose of it privately to the Selborne Society, who were willing to offer £50. There were but twenty people in the sale-room at the time, and the bidding remained entirely with some three or four individuals. Bidding started with an amount of no less than two hundred guineas, which was at once capped by one of two hundred and ten guineas, and eventually the manuscript was knocked down to Messrs. Pearson & Co., of Pall Mall Place, for two hundred and eighty guineas. The manuscript was in a capital state of preservation. This is the more remarkable, as it had been lying, for some time, treated almost as lumber, in a box in an old outhouse. Great care was manifest on every page on the part of the author. No haste showed itself. The regularity of the handwriting, careful and precise; the straightness of the lines, the apparent absence of haste in the preparation of the letters, all betokened the leisurely and careful habits of the writer.

At a recent meeting of the Victoria Institute, Sir George Stokes, Bart., F.R.S., took the chair, and papers by Sir J. W. Dawson, C.M.G., F.R.S., Profs. E. Hull, F.R.S., Parker and Dunns, the Rev. G. Whidborne and Mr. J. Slater, F.C.S., were read, upon the questions in regard to natural selection and evolution treated by Prof. Huxley in his recent address on "The Past and Present." It was pointed out that, as regards the Darwinian hypothesis of evolution, all naturalists admitted that it was as yet insufficient to account for man's place in nature, in fact was only a working hypothesis, and although one might recognize how magnificent in such master hands as those of Prof. Huxley had been the results of scientific methods, yet even he confessed to have met with mutual contradictions and intrinsic weaknesses in the hypothesis.

One of the most remarkable botanical achievements of this century has been obtained by Prof. Emery E. Smith, of California, who, by experiments in cross-fertilization, has succeeded in producing an entirely new violet, highly scented, and of great beauty. In size the flower covers an American silver dollar. Its colour is a clear violet purple, which does not fade. The fragrance is very powerful.

XUM

Dr. Donaldson Smith, who is on a scientific expedition to Lake Rudolph from the Somali coast, has certainly made a discovery that may rival in interest that of the wonderful sculptured stones, rock-buildings and pictographs on Easter Island. On his way south from the Shibeyli river he explored a river bed that ran under a mountain, and at the head of which he had learnt "the great god of the Gallas tribe had carved a palace to himself." He determined to solve the mystery, and his pluck was certainly amply rewarded. "We discovered," he writes to friends in America, "the most beautiful subterranean passages it would be possible to imagine. A large tributary of the river Juba had carved a way for itself under a mountain a mile in length. On either side of the stream were great vaulted chambers from twenty to forty feet high, and supported on massive columns." Had the learned reporter stopped here, speculation would have been confined to geological lines, and the explanation not a difficult one. But Dr. Smith proceeds to say that "the columns were most beautifully carved, and many of them joined, forming long arched passages. The mountain was hollowed out a great distance on either side of the stream." Fuller details of this very extraordinary discovery will be awaited with interest.

At a recent meeting of the Royal Meteorological Society, Mr. W. W. Shaw, F.R.S., delivered a lecture on "The Motion of Clouds," considered with reference to their mode of formation, which was illustrated by experiments. The question proposed for consideration was how far the apparent motion of a cloud is a satisfactory indication of the motion of the air in which the cloud is formed. The mountain cloud-cap was cited as an instance of a stationary cloud formed in air, moving sometimes with great rapidity. The two causes of formation of cloud were next considered—(1) the mixing of masses of air at different temperatures, and (2) the dynamical cooling of air by the reduction of its pressure without gain of heat from the outside. A sketch of the supposed motion of the air near the centre of a cyclone, showed the probability of the clouds formed by the mixing of air being carried along with the air after they were formed, while when cloud is being formed by expansion, circumstances connected with the formation of drops of water on the nuclei to be found in the air, and the maintenance of the particles in a state of suspension make it probable that the apparent motion of such a cloud is a bad indicator of the motion of the air. The meteorological effects of the thermal disturbance which must be introduced by the condensation of water vapour was referred to, and to this cause was attributed the violent atmospheric disturbances which accompany tropical rains.

At the annual Royal Society *conversazione* in May, phenomena associated with cloud formation were experimentally illustrated by Mr. Shaw. Clouds formed by mixture of two currents of air were shown in a large glass globe. The currents were due to convection. The motion of the clouds gave an indication of the motion of the air. Under suitable conditions the motion took a gyratory or "cyclonic" form. A second globe was arranged to show the formation of a cloud by the dynamical cooling of air, consequent upon a sudden expansion equivalent to an elevation of about ten thousand feet. The water globules could be seen to fall slowly. A light was arranged at the back of the globe to show (under favourable circumstances) coloured coronæ surrounding a central bright spot.

Mr. Jewell, from his investigations made at Baltimore, concludes that unless the amount of water in the atmosphere of Mars is greater than that in the earth's atmosphere, it is useless to look for the presence of water-vapour by means of the spectrum of Mars, unless the instruments employed are much superior to any hitherto used for that purpose. The chances of detecting the presence of oxygen do not seem so hopeless, and it is suggested that indications of the presence of the green colouring matter of plants might be got.

THE SUN'S STELLAR MAGNITUDE.

By J. E. GORE, F.R.A.S.

THE stellar magnitude of the sun is the number which represents its brilliancy on the scale in which the magnitudes of the stars are represented. In this scale the "light ratio," as it is termed, is now generally taken at 2·512, of which the logarithm is 0·4. This light ratio denotes that a star of the first magnitude is 2·512 times brighter than a star of the second magnitude, a star of the second magnitude 2·512 times brighter than one of the third, and so on.

In ancient times all the brighter stars were classed together as of the first magnitude, but as many of the so-called first magnitude stars, as Sirius, Arcturus, Vega, Capella, etc., are considerably brighter than other first magnitude stars, like Altair, Aldebaran, Spica, etc., this classification is not sufficiently accurate for the requirements of modern science. These very bright stars are, therefore, now considered as brighter than the first magnitude, and their brightness is sometimes represented by a decimal fraction, the scale thus beginning from 0 or zero. Sirius, the brightest star in the heavens, has been found by photometric measures to be about two magnitudes brighter than an average star of the first magnitude, like Altair or Spica, and its stellar magnitude may, therefore, be represented by $-1·0$, or one magnitude brighter than the "zero magnitude." Now, what figure would represent the brightness of the sun on this scale? The sun's brightness is so vastly greater than even a star like Sirius, that it might be supposed that a very large number would be required to represent its brightness in the stellar scale of magnitudes. This, however, is not the case. As will be seen, the relative brightness of the stars in the assumed scale forms a geometrical series, and increases very rapidly. Thus, a star of the average first magnitude is one hundred times brighter than one of the sixth, and ten thousand times brighter than a star of the eleventh magnitude, and so on.

Various attempts have been made to determine the sun's stellar magnitude, but owing to its excessive brilliancy its accurate determination is a matter of no small difficulty. Comparing its light with that of the moon, Wollaston, in 1829, found it 801,072 times brighter; Bond, in 1861, found 470,000, and (by another method) 340,000; and Zöllner found 618,000. These results are rather discordant, but Zöllner's figure has been usually accepted as the most reliable. Huygens found that the sun is 22·2 magnitudes brighter than Sirius; Wollaston, 25·75; Steinheil, 23·96; Bond, 24·44; and Clark, 23·89. The arithmetical mean of these determinations is 24·05. If, however, we omit the value found by Huygens, which is evidently too low, we have a mean of 24·51. Taking the magnitude of Sirius at $-1·0$, we have the sun's stellar magnitude $-25·51$. Prof. Pickering adopts 25·5, and this is the value which I have assumed in my previous papers in KNOWLEDGE.

As there seems to be an uncertainty as to the accuracy of this value, the following method of computing it has been suggested to me by my friend Mr. Monck. Taking

one of the larger planets when in "opposition," we can determine by the photometer its exact stellar magnitude. We can also compute the apparent diameter of the planet as seen from the sun, and thus ascertain the fraction representing the area of its disc compared with the area of the hemisphere illuminated by the sun. If the surface of the planet were a perfect reflector of light, we could in this way—knowing the distance of the sun and planet—compute the brightness of the sun in terms of the apparent brightness of the planet. But as no surface is a perfect reflector, a correction must be made for the "albedo," or reflecting power, of the planet in question. Let us see what result this will give in the case of Mars, Jupiter, and Saturn.

The mean of a number of determinations of the diameter of Mars, as seen at the earth's mean distance from the sun, gives about 9·4″. Reducing this to the mean distance of Mars from the sun, I find that the mean diameter of Mars in opposition, as seen from the sun, is 6·17″. This gives the area of its disc 29·9 square seconds. Now, in a hemisphere of the star sphere there are 20,626·5 × 12,960,000 = 267,319,440,000 square seconds, and hence area of hemisphere = 8,940,450,000 times the area of the disc of Mars as seen from the sun. Hence, if the surface of Mars were a perfect reflector, the sun as seen from Mars would be 8,940,450,000 times brighter than Mars appears to us when in opposition. But Mars is not a perfect reflector. Its albedo, or reflecting power, is, according to Zöllner, only 0·2672 (that of a perfect reflector being 1); hence we must divide the above number by 0·2672, which gives 33,459,768,000 for the ratio of the light of the sun to the reflected light of Mars. Now, as the mean distance of Mars from the sun is 1·5237 (that of the earth being 1), we must multiply the above result by the square of 0·5237, or 0·2742, to obtain the light of the sun as seen from the earth. This gives the light of the sun as seen from the earth 9,174,668,385 times the light of Mars when in opposition, a number which corresponds to 24·9 stellar magnitudes. Now, Prof. Pickering finds the stellar magnitude of Mars at mean opposition to be −2·25, that is $2\frac{1}{4}$ magnitudes brighter than a star of the zero magnitude, or about $1\frac{1}{4}$ magnitudes brighter than Sirius; hence we have the sun's stellar magnitude, as deduced from the apparent brightness of Mars − (24·9 + 2·25) = − 27·15, a considerably higher mean than that usually adopted.

Let us now see what value can be derived from the planet Jupiter. The mean diameter of Jupiter as seen from the sun (allowing for the ellipticity or compression of its disc) may be taken—as the result of five determinations by different astronomers—at 36·4″. This gives an area of disc = 1040·6 square seconds, and a ratio of the area of the hemisphere to that of Jupiter's disc = 256,889,717. Dividing this number by Jupiter's albedo, as found by Zöllner, viz. 0·6238, we obtain 411,814,230 for the ratio of the light of the sun to the reflected light of Jupiter. Now, as the mean distance of Jupiter from the sun is 5·2028 (that of the earth being 1), its distance from the earth, when in opposition, is 4·2028, and we must multiply the above number by the square of this, or 17·663, which gives 7,273,874,744, a number which corresponds to 24·65 stellar magnitudes. Prof. Pickering finds the stellar magnitude of Jupiter in opposition to be −2·52, and adding this to 24·65 we obtain − 27·17 for the sun's stellar magnitude, a result in close agreement with that found from Mars.

In the case of Saturn, we may take its mean apparent diameter, as seen from the sun, at 16·8″ (allowing for the ellipticity of its disc). This gives an area of 221·67 square seconds, and a ratio of the area of the hemisphere to that of Saturn's disc of 1,205,934,244. Dividing this number by Saturn's albedo, 0·4981, as found by Zöllner, we obtain 2,421,068,548 for the ratio of the light of the sun to the reflected light of Saturn. Now, as the mean distance of Saturn from the sun is 9·5388, its distance from the earth when in opposition is 8·5388, and we must multiply by the square of this, or 72·9111, which gives 176,522,771,010, a number which corresponds to 28·11 stellar magnitudes. Now it has been found by photometric measures that Saturn, when in opposition, and the rings invisible, is about equal in brightness to Aldebaran, which may be considered as a standard star of the first magnitude. Hence we have the sun's stellar magnitude = −27·11, a result in close agreement with those found from Mars and Jupiter.

From the above calculations we see that, on the lowest estimate, the sun's stellar magnitude is at least −27. If this result be correct, the results arrived at in my paper on "The Distance and Mass of the Binary Stars" will require considerable modification. The magnitudes there found for the sun, supposed placed at the distance of the binary star, would have to be diminished by 1·5 magnitude. Thus, in the case of γ Leonis, the sun at the distance indicated by the hypothetical parallax would shine as a star of 8·29 − 1·15 or 6·79 magnitude, denoting that γ Leonis is only sixty-six times brighter than the sun. This would diminish the parallax of 0·58″ to 0·29″, and would increase the mass of the system eight times, or to about $\frac{1}{500}$th of the sun's mass. Similar corrections would have to be made in the case of the other binaries discussed in my paper, the general result being to increase the mass of each system eight times. For ξ Scorpii we should have a mass of about $\frac{1}{9}$th of the sun's mass; for ι Leonis the mass would be about $\frac{1}{6}$; for 35 Comæ about $\frac{1}{3}$, and for τ Cygni about $\frac{1}{4}$, results which are perhaps more probable than those found in my previous paper. In the case of the other binary stars, however, referred to in that paper, the masses would still be small. For π Cephei we have a mass of about $\frac{1}{50}$; for ω Leonis about $\frac{1}{24}$; for β Delphini $\frac{1}{22}$; for τ Ophiuchi $\frac{1}{17}$, and for ξ Aquarii $\frac{1}{24}$. An opposite effect would, of course, be produced in the remarkable case of μ^1 Herculis. Here the sun would shine as a star of 4·5 magnitude, if placed at the distance indicated by the hypothetical parallax (0·107″), denoting that the sun is about one hundred times brighter than the star for equal masses. To reduce the sun to a 9·5 magnitude star, the parallax should be reduced to 0·01″, and this would increase the mass of the system to one thousand two hundred and forty times the mass of the sun.

We may compare the relative brightness of the sun with that of binary stars having spectra of the solar type. Suppose an imaginary planet to revolve round the sun at $\frac{1}{100}$th of the earth's distance from the sun; the period of revolution would be $\frac{1}{1000}$th of a year, and the semi-axis major of its orbit, as seen from the earth, would be $\frac{206265}{100} = 2062{\cdot}65''$. Substituting these values of P and a in Mr. Monck's formula (given in my catalogue of binary star orbits), and taking the sun's stellar magnitude at −27, I find that the relative brightness of the sun, compared with that of ξ Ursæ Majoris (which has a spectra of the solar type), taken as unity, is 1·2748. Conversely, if we assume the brightness of the sun to be equal to that of ξ Ursæ, I find that the sun's stellar magnitude would be −26·73.

Assuming the sun's stellar magnitude at −27, I find that the sun would be reduced to about the same brightness as α Centauri if placed at the distance indicated by a parallax of 0·76″ found for that star. The spectrum of α Centauri is of the solar type.

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With reference to the results given in my paper on "Globular Star Clusters," as an increase of 1·5 magnitude in the sun's stellar magnitude implies an increase of its computed brightness about four times, it would be necessary to remove it to double the distance given in my paper in order to reduce it in brightness to stars of the fourteenth magnitude. This would double the diameter of Omega Centauri, which is supposed to be placed at the same distance, and would proportionately increase the distance between the components of that wonderful cluster of suns.

THE SUN PILLAR.

By the Rev. SAMUEL BARBER.

THIS very unusual and striking optical phenomenon was seen in its full brilliancy, though only for about fifteen minutes, at Westnewton, near the Cumberland coast, shortly before sunset, on January 30th, 1895. The unusually severe frost prevailing at the time was characterized by other rare appearances, *e.g.*, the white rainbow formed in the upper sky.

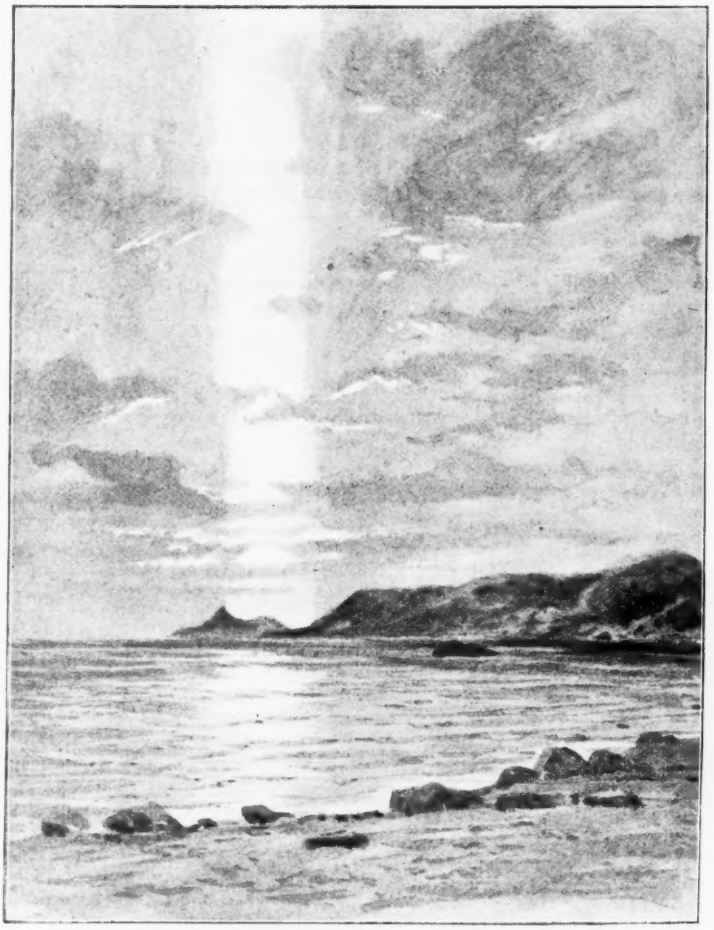
This sun pillar was highly luminous, almost like a continuation of the sun itself, making it appear like a huge comet with a tail of even breadth with its own disc, and equally brilliant in its entire length. Light fleecy clouds, not cirrus, but a loose drift of half stratified "alto cumulus," were drifting above the declining orb of day from E.S.E. I may note here that this variety of cumulus certainly contains, at times, quantities of ice-prisms. It has been almost continually prevalent during the long frost of January and February, 1895, accompanied by bands of strato-cumulus of loose texture and smoky tint. The occasional formation of a pseudo-nimbus in the east, soon to clear away, was another characteristic of this frost. A similar phenomenon occurs during drought in summer.

The appearance of the sun column as observed by Roth is recorded in Kaemptz's "Meteorology." This observation of Roth was most remarkable, the column having appeared before the sun had risen, and containing a parhelion, which was mistaken at first for the true sun. The sun shortly after rose, and the column of light followed underneath it and contained *another* parhelion.

Kaemptz himself has hit upon the right explanation of this phenomenon, by a careful deduction from an observation which he made on January 23rd, 1838. On that occasion both the upper and lower parts of the column were visible; many luminous frozen particles were floating in the air, and upon examination these proved to be isolated hexahedral *films*, about the size of a pin's head. Kaemptz rightly points out that there are no phenomena of refraction here; it is simply reflection, and in this he agrees with Brandes.

The observation now recorded, taken by myself at Westnewton, is valuable as agreeing with and confirming Kaemptz's account, which is, indeed, a model of exact description. The height of the above column was similar in both cases, the air contained ice-crystals, and the breadth of the column was also the same.

In excluding refraction from the originating causes of the sun pillar, Kaemptz raises a difficulty in explaining the parhelia described by Roth; for it is admitted that



Sun Pillar, seen at West Newton, Cumberland, January 30th, 1895.
(From a sketch by Rev. S. BARBER.)

refraction is the usual source of these latter appearances. They almost invariably exhibit the colours which correspond to the refraction angles of ice-prisms. But for all that, it is undoubtedly reflection which must account for the sun pillar.

Let the reader consider the case of the long column of light cast by the sun upon the smooth surface of a lake, or a calm sea, when near the horizon. Though broken by a slight movement of the water, the bright band is normally of the same width as the sun's apparent disc, which has its full diameter projected upon the watery mirror throughout the whole length of the column, wherever equiangular incidence of the light is possible. This equiangular incidence is, of course, only possible in a line drawn directly from the observer to the emitting body of light, whenever the reflecting surface is horizontal. Thus, bands that seem to pass horizontally through the sun are produced by the reflecting facets of crystals floating vertically; but upright columns which pass vertically through the sun's disc are the result of crystals or prisms that float *horizontally*.

An examination of ice-crystals with a good lens will show their immense variety. Replying to the question "why are some halos concentric with the sun, while others pass through the disc?" Kaemptz says: "If it were possible to study the crystals of snow that reflect and refract the light, it would be easy to reply to that question. It appears to me probable that these differences are due to different forms that the crystals may assume. If they are prisms floating in the air, a luminous circle is produced by refraction; if they are lamellated crystals, the reflection produces a parhelic circle passing through the sun." Now, those who, like the present writer, have carefully examined a shower of ice-crystals, will know the endless varieties that fall in the same shower. It is not, therefore, surprising to find both kinds of halos at times represented in one phenomenon. Such appearances are recorded in treatises on meteorology, and an instance occurred, as recorded by Mr. C. Wood, of Middlesborough, on the evening of July 22nd, 1894, at Redcar. The present writer witnessed a very similar appearance on July 11th, at Westnewton, Aspatria. Mr. Wood speaks of circles of "cirrus form of cloud." I need hardly remind the reader that these geometrical figures are due to optical law, and were no cloud visible the result would be the same, and the colours more perfect, if the crystals were there in sufficient quantity. This I have confirmed by a variety of observations.

Speaking of the quantity of these ice-crystals floating in the air, a remarkable observation of the sun pillar is given by Lohrmann, seen near Dresden, on the evening of one day and the morning of another, and repeated on several occasions afterwards. The calculation was made some time ago that if all the vapour contained in solution by the atmosphere fell in snow, the whole earth would be covered to a depth of twenty feet. This gives us an idea of the countless multitudes of crystals which may be present in one perspective view of the heavens. In accounting for the sun pillar in its vertical form, I have cited, as analogous, the band of light reflected from still water. It may be objected that the particles of water are continuous, but the atmospheric ice-crystals are not so. But the particles of water are not *absolutely* continuous—indeed, no particles of any form of matter are—and the number of ice-prisms is quite sufficient, at times, to produce the optical effect now described. A more closely related instance of an apparently continuous band reflected from separated points is to be found in the beam of motes projected into a darkened room through the aperture of a shutter.

In conclusion, we may note that these optical phenomena of the white rainbow and the sun column derive additional interest and significance from the continuance of the "historic" frost with which they have recently been associated.

THE PROGRESS OF SELENOGRAPHY.

By Arthur Mee, F.R.A.S.

ANY moonlight night two hundred and fifty years ago, whilst the good people of Dantzic were wrapped in slumber, one of the wealthiest burghers of the Prussian city might have been found deeply engaged in the contemplation of our satellite. His observatory was very different from what we associate with the name, and his clumsy and imperfect telescope a modern amateur would cast aside with contempt. But though his apparatus—the most perfect of his day—was to our way of thinking absurdly inadequate, Hevelius possessed those qualities which make the successful observer, and his great skill, his splendid energy, and his untiring perseverance made up in no small degree for the imperfection of his instruments. Night after night he watched, drawing after drawing was carefully secured, until, at the end of several years, he found himself possessed of sufficient material to lay down a chart of the moon. Here, again, our astronomer spared no pains in the execution of his task. He drew his map eleven inches in diameter with minutest care, he engraved it on copper with his own hand, he wrote a treatise on what he had discovered, and he gave the whole to the world in the shape of a folio volume with a ponderous Latin title, after the fashion of the times. Quaint in the extreme is this old map, with its mountains in perspective, its lands, its oceans, and its rivers all carefully christened by the author, and last, but not least, the winged cupids in the corner bearing scrolls descriptive of the chart and its abbreviations.

Such was the earliest map of the moon. Galileo had observed the spots, Scheiner and Langrenus had drawn them, but it was left to Hevelius to construct the first chart which, though of no great value to the modern student, must ever remain a monument to the patience and skill of the father of selenography. It was not long before Hevelius' map had a rival in that of Riccioli, of Bologna, prepared from Grimaldi's observations. Hevelius had been content to name the various objects from presumed terrestrial analogies; but Riccioli, with a touch of human vanity, conceived the idea of christening the various formations after the philosophers of his own and of ancient days. In carrying out this scheme of nomenclature, the Bolognan observer was careful to include his name as well as that of Hevelius, and, as Riccioli's system was accepted, the pair are still found side by side on our modern maps of the moon.

For a whole century the chart of Hevelius remained the chief lunar authority. Cassini and others had, indeed, made attempts in the same direction, but no advance was recorded until Tobias Mayer, of Gottingen, determined on a new map. During the lunar eclipse of 1748 he felt the want of an accurate chart, and set to work to prepare one in twenty-five sections. He had collected his materials when death cut short his work at the early age of thirty-nine years. A small map embodying his observations was, however, issued; but the large one did not see the light till a few years ago, when it was produced under the editorship of Klinkerfuss.

Another long interval elapsed, and then Schroeter, of Lilienthal, applied himself to the study of the moon. He did not construct a map, but he published a series of careful drawings, as he tells us, with the express object of leaving to his successors materials for settling the question of lunar change. Up to this time, and, indeed, until the publication of the great work of Beer and Mädler, the moon was considered to be a living world, with lands and seas, and rivers—with forests and active volcanoes, and, perhaps, with sentient beings inhabiting its surface. Schroeter's labours, therefore, were invested with peculiar interest, and were carried out with all the zeal and earnestness that characterized those of Hevelius, but with instruments far superior to those which the older philosopher possessed. Miss Agnes Clerke justly styles Schroeter the originator of selenography in its modern sense, and his vicissitudes, no less than his devotion to astronomy, deserve that the story of his most interesting life and labours should be given in detail to the world. Schroeter was not a skilful draughtsman, but he made his designs

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with the greatest care and patience, and his work is still of much service in elucidating disputed points in selenography.

Schroeter's study of the moon practically ended with the eighteenth century, and nearly twenty-five years passed before another marked advance in selenography took place. W. G. Lohrmann, of Dresden, was the next to take up the work, and he commenced the construction of an accurate chart thirty-seven and a half inches in diameter. Like Mayer, he was not destined to finish it. A smaller map was issued just before his death, and a larger one was published in 1878, under the editorship of the great selenographer, Schmidt. A contemporary of Lohrmann was Gruithuisen, like him, a draughtsman of great excellence, of whose drawings, published some years ago, no less an authority than Klein has expressed himself in terms of highest praise.

The years 1836-37 marked an epoch in lunar science, for they witnessed the publication of Beer and Mädler's great map and text-book on the moon. The chart, thirty-seven and a half inches in diameter, is still esteemed an authority, and the monograph sufficed to settle for many years the problem of active forces at work upon the surface of the moon. Besides their great chart, Beer and Mädler issued a smaller one, which for beauty, accuracy and moderate price, deserves much wider recognition than it appears to have received, at any rate in this country.

Once more a lull occurred in the advance of lunar science, till at length the rapid increase in the power and excellence of telescopes again forced the question of lunar change to the front. Selenography, so long neglected in England, was quickened by the action of the British Association, which appointed a committee to investigate the matter and to collect material for an adequate chart of the moon. It was decided by the committee to draw up an outline map two hundred inches in diameter. A portion of the work had been completed when, for some reason or another, the committee was dissolved. That enthusiastic student, the late Mr. Birt, attempted to carry forward the work, which was also helped on by the Selenographical Society; but the latter, in its turn, to the great and permanent loss of lunar science, succumbed after an all too short existence. More recently the Liverpool Astronomical Society, and (in especial) the British Astronomical Association, have accumulated much material of value, thanks in the main to the labours of Mr. Thomas Gwyn Elger, one of the most honoured names in the English annals of selenography.

Before leaving our own countrymen, mention must be made of the labours of Phillips, and of the text-books of Nasmyth, Proctor, and Neison (now Nevill, Government Astronomer at Natal). Nasmyth's elaborately illustrated monograph is based on a series of finely executed models of the lunar surface, which, for general effect, have never been surpassed. Proctor's handbook is noteworthy for the skill displayed in handling the mathematical aspect of our satellite. Neison's great work, with its outline map, is a monument of patient labour, badly in need, after nineteen years, of a second and revised edition.

We have seen what selenography owes to German students, nor have we yet exhausted the list, for there remains to notice the great chart of Julius Schmidt, six feet in diameter, the labour of thirty years, and containing no fewer than thirty-three thousand objects. This masterly production, given to the world in 1877, represents the furthest complete advance in lunar cartography, but the time is soon coming when a much larger and more elaborate map will be required to keep pace with the progress of observation. To the bulk of amateurs the price of Schmidt's chart renders it inaccessible. Neison's is, however, an excellent substitute, and smaller but very perfect maps are those of Mädler (already mentioned), Mons. Gaudibert (a very fine production), Prebendary Webb (in his "Celestial Objects," with its charming description of the moon), and Mr. T. K. Mellor. Mr. Elger also has just issued a map and handbook, which are of the greatest possible interest and value.

So far we have dealt with drawings and charts of the moon; we have merely mentioned the elaborate models of Nasmyth, and have said nothing of such paintings as those of Harrison and others. But space demands that we pass to what bids fair to revolutionize the art of lunar delineation, and to greatly advance our knowledge of the constitution of the moon, if not to unlock its long-hidden secret. When, in 1840, the distinguished American scientist, Dr. John William Draper, secured the first photograph of the moon, he little thought what splendid triumphs the sensitive plate would achieve in the ensuing half century, or that the chemical image would far outrun the most skilful fingers in depicting the intricate scenery of the lunar surface. The earlier moon photographs were small and comparatively uninteresting, but increased attention was given to the subject, and in the sixties Dr. Rutherfurd, of New York—to mention but one worker out of many—achieved very noteworthy results. It was soon found that, by enlarging these photographs, considerable detail could be made out; but not until the great reflector on Mount Hamilton was turned upon the moon were the possibilities in this direction fully realized.

In 1888, Prof. Burnham was placed in charge of the photographic work of the great thirty-six inch telescope, and secured a number of negatives of unsurpassed excellence and beauty. In 1890 the work was renewed by Dr. Holden and others, with the object of securing a series of photographs so complete as to cover the whole history of a lunation, and to include photographs made at various critical stages of libration. It was soon found (Dr. Holden tells us*) that the Lick negatives "contained a wealth of detail quite unknown in previous work of the kind, and that they were admirably suited to provide the data for a new study of the moon's topography." It was impossible to examine the negatives properly at Mount Hamilton, and negotiations were, therefore, opened with Prof. Ladislas Weinek, director of the Imperial and Royal Observatory of Prague, an astronomer of great experience and an exquisite draughtsman.

Sets of Lick photographs were placed at Dr. Weinek's disposal, and he tells us minutely in the Mount Hamilton "Publications" how he proceeded with the work. Meanwhile experiments in enlarging had been made at the Lick Observatory, both directly in the telescope and also by subsequent exposure in the camera. The former were not particularly successful. The latter showed that enlargement up to a scale of three feet to the moon's diameter, and even more, was perfectly feasible. Such photographic enlargements were also made elsewhere; amongst others by Baron Rothschild, of Vienna, Mons. Nielsen, of Copenhagen, and Mons. Prinz, of Brussels.

Dr. Weinek, when he commenced his work on the Mount Hamilton negatives, was dissatisfied with these photographic enlargements, and determined to turn his great skill as a draughtsman to account by making enlarged pencil drawings from the original photographs examined by transmitted light under a magnifier. Equally astonishing are the labour expended and the beauty and accuracy of the results, the enlargements being the most graphic and correct representations of the lunar surface

* *Publications of the Lick Observatory*, Vol. III., 1894.

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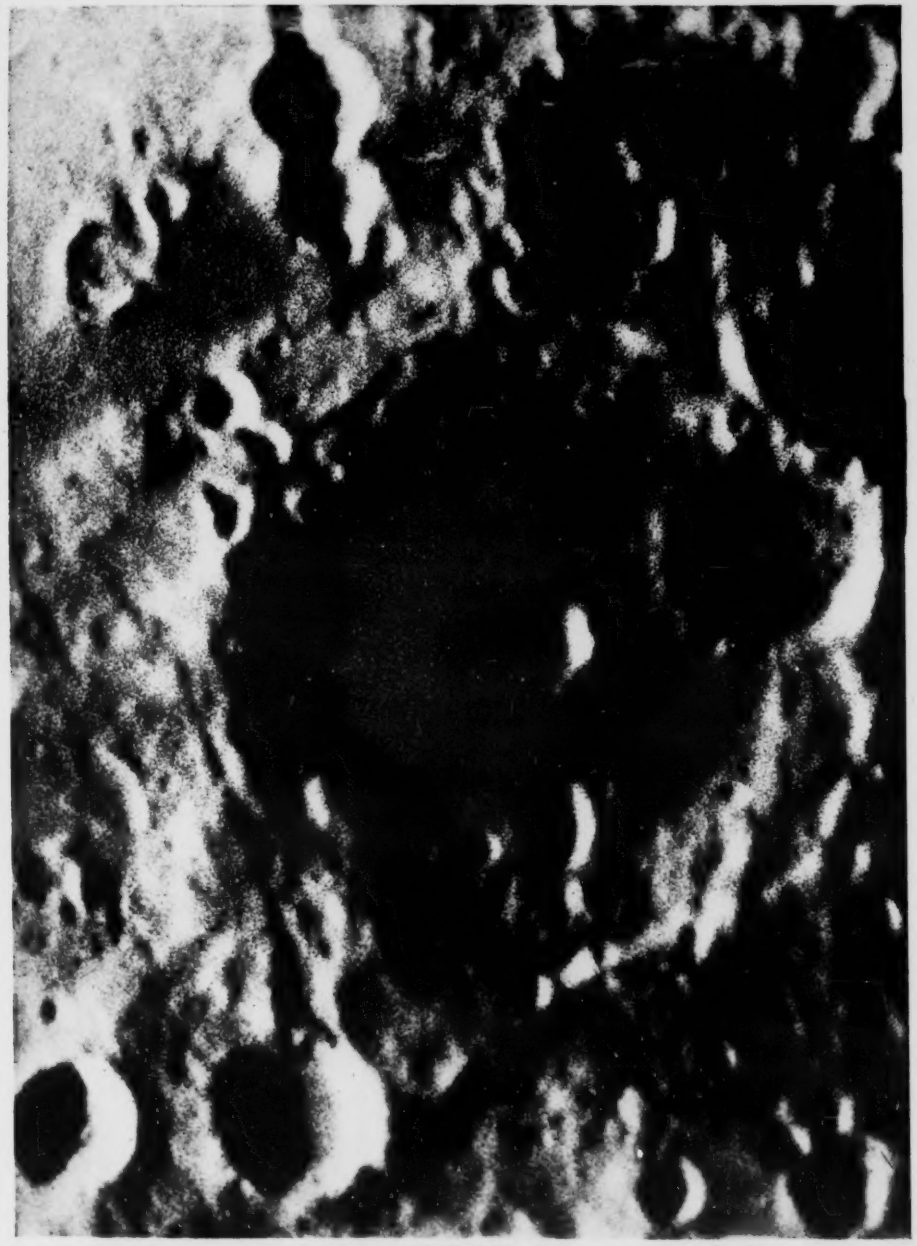
SOUTH.

NORTH.

MAUROLYCUS.

SOUTH.



NORTH

ALBATEGNIUS.

From enlargements by Dr. L. WEINEK of a photograph of the Moon taken by MM. LOEWY and PUISEUX with the 60 c.m. Equatorial Coudé of the

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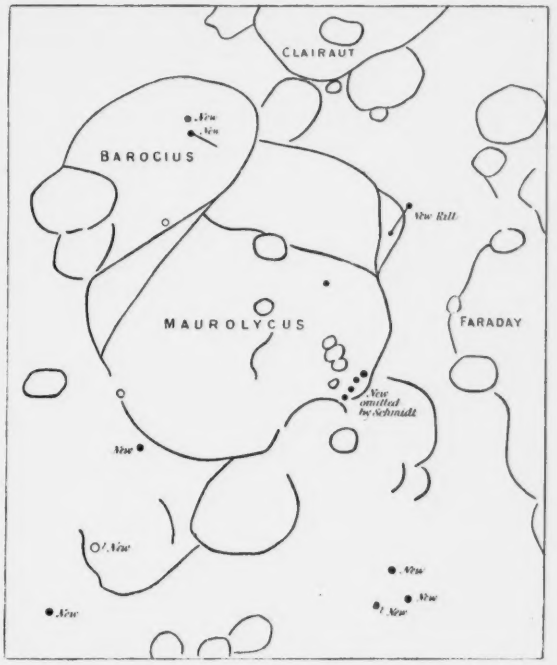
that have ever been produced. When these enlargements first appeared their revelations were received in many quarters with incredulity, but close examination tends to confirm their correctness and to render certain the existence of the minutest details, not only in the photographs, but on the moon itself.

These magnificent hand enlargements, as we have seen, cost Dr. Weinek immense labour. His study of Copernicus alone occupied him two hundred and twenty-five hours. The distinguished astronomer was then led, in conjunction with Dr. Spitaler, to study closely the problem of photographic enlargement, and has been fortunate enough to discover a method (which for the present he reserves) of greatly reducing the grain, the *crux* of the whole problem of enlargement. The results achieved by the new process are remarkable, especially when we study them as applied to the moon photographs obtained at the Paris Observatory by Messrs. Loewy and Puiseux of that establishment. These photographs are obtained with an equatorial *coudé* of eighteen mètres (sixty feet) focus and sixty centimètres (thirty-three and a half inches) aperture, with an exposure of half a second. They are exquisite productions, and superior, if that were possible, to the Mount Hamilton photographs. Dr. Weinek has enlarged portions of them to a scale of thirteen feet to the moon's diameter, that is, double the scale of Schmidt's celebrated chart.

An examination of these enlargements shows, as was to be expected, much detail not found on the finest maps, and they will be of the highest value in the production of the next great chart of the moon—a chart which will as much surpass the classic map of Mädler as Mädler's does the quaint map of the old selenographer of Dantzic.

[Dr. Weinek has very obligingly forwarded two of his enlargements of portions of the moon, to illustrate Mr. Mee's paper. The original photograph was taken by the Brothers Henry on March 14th, 1894, at 6h. 33m. 57s., Paris mean time, and the enlargements as made by Dr. Weinek were on a scale of four mètres to the lunar diameter, a magnification of 23·36 times linear. In the accompanying reproductions a scale of two and a half mètres to the lunar diameter has been employed, the actual scale, therefore, being somewhat greater than that of Schmidt's great map. The two regions represented are Albategnius and Maurolycus. Both are well known as amongst the finest examples of lunar walled-plains. The former was included in the photograph of "Sunrise on Ptolemaus," published in the number of KNOWLEDGE for December, 1894, Albategnius and Ptolemaus being neighbour formations. It is 64·6 miles in diameter, and is surrounded by a mountain wall of great height and steepness, the loftier peaks of which have a height of ten thousand feet or more. The principal new marking discovered by Dr. Weinek in this region is a crater pit about two miles in diameter, on the level floor of Albategnius and S.W. of the central mountain, about halfway from it towards the outer wall. The region of Maurolycus has been much more fruitful in new objects, some of which are indicated in the little sketch-map subjoined. Amongst these, special attention may be drawn to the chain of four crater-pits just within the east wall of Maurolycus, and a very distinct rill proceeding from a newly-discovered crater-pit and crossing the outer southern wall of the plain. Two new objects are also shown on the floor of the ring-plain Barocius, from one of which a rill proceeds in a N.E. direction.

I should like to add just a few words to Mr. Mee's admirable *résumé* of the progress of selenography, and to refer to by far the most complete collection of lunar photographs at present in existence, that taken under the direction of the late Prof. Pritchard with the twelve-inch De la Rue reflector at the Oxford University Observatory. The photographs, which exceed one thousand in number,



were taken for the purpose of measuring the lunar libration. Though from their small size—the image of the moon being scarcely more than an inch in diameter—they cannot compare with the photographs taken recently at Lick and at Paris, yet many of them show much beauty of detail, and bear considerable enlargement.—E. WALTER MAUNDER.]

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

FLUCTUATIONS OF MIRA CETI.

To the Editor of KNOWLEDGE.

SIR,—The letter on Mira in the March number of KNOWLEDGE leads me to ask, what has been the experience of observers of that star this year on your side of the Atlantic?

The writer, working with a field-glass, has seen two maxima and two minima of Mira, also two each of R Leonis, during the past month, and a well-known astronomer, who confirms these observations, saw similar fluctuations of R Trianguli about the same time.

The two first named are still visible—Mira as 4·5 magnitude and R Leonis as 5·3 magnitude.

Yours faithfully,

Memphis, Tenn., U.S.A., DAVID FLANERY.
15th March, 1895.

[The following three letters from experienced observers of variable stars on the point raised by Mr. David Flanery do not directly confirm his observations; though the difference in the date of maximum as fixed by Herr Plass-

mann and by Col. Markwick is at least not inconsistent with them, and the latter observer is ready to accept a *slight* variation in the light of Mira near maximum.—E.W.M.]

SIR,—During the month of February, 1895, I could only observe a steady increase in the light of Mira Ceti. The fluctuations observed by Mr. David Flanery can be explained, I venture to think, by errors of observation; especially from the influence of twilight and of the full moon of February 9th. When I say that the light of Mira was on the increase throughout the month of February, I mean up to February 15th or 20th, when the maximum was reached. Yours very truly,

J. PLASSMANN.

DEAR SIR,—I can quite endorse the statement of Mr. Flanery as to fluctuations of light of some of the long period variables at maximum. I think there can be no doubt that at or near the maximum the light varies a little; in the case of Mira, hardly enough, however, to enable the deduction to be drawn that *two* maxima had occurred. The curve of brightness of Mira, for season 1886-7, as delineated on p. 303, Vol. IV., *Journal of the British Astronomical Association*, will show what I mean. The general "mountain," or "hump," is broken by several small hillocks or irregularities which are hardly high enough to be called separate maxima. This season my observations of Mira indicate the same phenomenon. The day of actual greatest brightness was March 12th. Of course, too much stress should not be laid on small differences of brightness, for they may not always be real, but be due to errors of judgment in estimating brightness, to the varying brightness of the background on which the star is seen, and last, but not least, to the notorious difficulty of estimating correctly a ruddy star, such as Mira is at maximum.

I have noticed the same feature in U Orionis (see p. 531, Vol. LIV., *Monthly Notices, R.A.S.*), and think that, after making allowance for all possible sources of error, there is a real fluctuation, in the case of the above-mentioned stars, similar to what is seen in the curve of sunspot frequency. Yours sincerely,

Ordnance House, Gibraltar, April 11th, 1895. E. E. MARKWICK.

DEAR SIR,—I am sorry not to be able to say anything for certain about Mr. Flanery's observations, as neither of his stars are on my working list. Judging, however, by analogy, I should require very strong evidence before I placed much confidence in the observations.

In my opinion very little faith can be put in visual observations to less than a magnitude, unless several comparisons are made with stars of which the magnitudes have been accurately estimated beforehand. In my own observations, I always compare with five stars, of which I have estimated the magnitudes over a period of at least six months, taking the mean value as my result.

Yours very truly,

25, Bryanston Square, April 10th, 1895. C. E. PEEK.

[Mr. Flanery writes again, under date April 11th, to point out that R Leonis appeared to him to reach its maximum on March 22nd-23rd, twenty-two days ahead of the time predicted by Mr. Sadler (KNOWLEDGE, for April, p. 94), and that this is the second year that this has happened. Mira, on the other hand, was many weeks behind time, fluctuated greatly whilst under observation, and at its brightest did not reach much more than 4·5 magnitude.]

PRISMATIC COLOURS ON THE CLOUDS.

To the Editor of KNOWLEDGE.

SIR,—I have recently observed on several occasions the phenomenon of prismatic colours on the clouds, caused by the sun shining through a thin veil of cirrus or cirro-cumulus. Sir J. Herschel ("Lecture on Optics") alludes to this as an "extremely rare phenomenon," which is doubtless true as regards England, but in this clear atmosphere I have seen it four times during the last two months, though I did not remark it during the earlier part of the year.

The colours are not vivid, but may be described as beautiful transparent flushes, like those on the haliotis and other well-known ornamental shells. This morning they were more perfect than I have seen them before, and formed a double circle round the sun on a veil of light cirro-cumuli, passing at a great rate, the tinge next the disc being opalescent white, then rose-pink, and beyond a greenish-blue, the two latter being repeated, after an interval, on the second ring. At one point all the prismatic colours were visible, but less brilliant, of course, than in the spectrum. Beneath, near the horizon, was a long, wavy line of milky-white cloud, of which the brightness varied slightly, brighter patches seeming to shift along it.

The parhelia of Arctic voyagers are represented here by the not infrequent appearance of irregular, faintly prismatic patches ("sun-dogs") on each side of the sun when low. I have only once or twice seen two, and then the right hand patch was much the fainter. Commonly only the one on the left of the spectator is visible. The phenomenon of "moon-dogs" is much rarer. On the one occasion that I have seen it, only one was visible, and that was colourless.

It is not uncommon to see auroral appearances in the daytime. On the afternoon of October 30th, between three and five, I saw an unusually extensive display, the sun being about twenty degrees above the horizon. An arch of a smoky-brown colour advanced and raised itself nearly to the altitude of the sun. At one time it formed quite a broad band, then grew thinner, varying again more than once. Below it were several broken bands of the same colour, fringed with opalescent white, and below them a darker strip of a dull coppery purple. Early in the phenomenon I saw a milky hue, in a thin irregular band, spread itself to some distance over the clear sky, something like a streamer in the nocturnal displays, only horizontally instead of vertically. On the horizon were small irregular bands of a coppery colour, but displaying faintly prismatic tints. At one side of the large arch a small strip of sky was of a beautiful green; a green tint was also observable in the opposite quarter of the horizon. Perhaps this was due to the contrast between the blue and the dun colour of the arches, or perhaps to the spreading of a strip of opalescent white over clear sky.

The appearance of an auroral cloud at the same time as the prismatic colours in the first-described phenomenon seems a curious coincidence, if nothing more. I should be grateful for any further information on the point, and also with regard to the so-called "sun-dogs."

Ebor, Manitoba. ARTHUR PARRY, B.A.

[The "phenomenon" of the prismatic colours on the clouds may be observed frequently when nearing the snow line on the Swiss Alps.]

NOTE.—The first part of this description seems to refer to corona rather than halo; corona being generated by water refraction, halo by that of ice. Very beautiful colours do occur, though rarely, in coronæ; but prismatic colours in clouds are not a great rarity, excepting in a very brilliant form. There ought always to be *some* colour

when the solar rays pass clear through cirrus. "Sun-dogs" appear to be formed when the refracting crystals are limited to a small area of cloud. Parhelia, in hot weather, usually develop a patchy mass of prismatic light, which sailors would call "sun-dog." The subject is a wide one.—S. BARBER.

MIRAGE IN THE DESERT.

To the Editor of KNOWLEDGE.

SIR,—I wish to know in what position the sun is during the phenomenon of a mirage in the desert? Is it opposite to the appearance, as in a rainbow? Is the sky of the desert land blue or a glare of white? (I am not alluding to sunrise or sunset.) Is colour traced in the mirage, or merely a neutral, misty appearance? I have heard statements made contradictory one to the other. People seem to know very little on the subject.

Yours truly,

(MISS) F. STEPHENS.

Fern Cottage, Lincoln Road, Dorking.

[In the mirage of the Sahara and other arid deserts, the soil has become heated by the presence of the sun, and the prospect seems bounded by a general inundation, not depending upon the exact position of the sun as in the rainbow and mountain-giants. The observer sees in the distance the reflection of the sky and of terrestrial objects, as on the surface of a calm lake. The terrestrial objects have, of course, an inverted image. The distance of the apparent water is so great that the colour of the sky and terrestrial objects cannot be discriminated, any more than at a distance the inverted images of trees are seen in a Highland lake. The villages beyond appear as islands in the midst of a great lake. Under each village its inverted image is seen as it would be if reflected from the surface of a sheet of water. On approaching, however, the deceptive inundation recedes, and the reflected image vanishes, to be succeeded by another, as some more distant object comes in sight. It is explained by the heating and consequent rarefaction of the air in contact with the hot soil. The density in the lowest stratum of air (a foot or so in thickness) increases upwards, and rays entering this stratum at a small inclination are bent upwards in a manner resembling "total reflection," but with the corner rounded off. Skylight rays descending become bent upwards; the eye receives an impression resembling that produced by the reflection of skylight from water. The illusion is rendered more perfect by the flickering due to convection currents, which causes an appearance like a breeze playing over the illusory water.—J. G. McP.]

Notices of Books.

Molluscs and Brachiopods. By the Rev. A. H. Cooke, M.A., A. E. Shipley, M.A., and F. R. C. Reed, M.A. Pp. 535. (Macmillan and Co.) 17s. The Cambridge Natural History, of which this volume is the first published instalment (though it is really the third volume in a series of ten), is intended, to quote the publishers' circular, "in the first instance, for those who have not had any special scientific training, and who are not necessarily acquainted with scientific language. At the same time, an attempt is made, not only to combine popular treatment with the latest results of modern scientific research, but to make the volumes useful to those who may be regarded as serious students in the various subjects. Certain parts have the character of a work of reference." We think, however, judging from the volume before us, that the general reader will find the series unsuitable for his mental digestion. For instance, on the third page, a tropical beach is described in this manner: "On the rocks at high water mark, and even above them, occur *Truncatella*, *Melampus*, *Littorina*, and *Siphonaria*; where a mangrove-swamp replaces the rock, on the branches overhead are huge *Littorina*, while three species of *Cerithidia* crawl on the mud, and *Cyrena* and *Arca* burrow into it. Lower down, in the rock pools at half tide mark are *Cerithium*, *Purpura*, *Omphalius*, *Anachis* (2 sp.) *Nassa*, and several *Crepidula*." The description runs on in the same strain for a whole page. Of course, it cannot be held for a moment that readers unacquainted with malacological nomenclature can have the faintest interest in such an enumeration of forms of molluscan life, and by no stretch of imagination can it be regarded as a pabulum in which the public "who are not necessarily acquainted with scientific language" will find delight. But though the work does not appeal to those who like to assimilate knowledge almost unconsciously, it is undoubtedly readable in many of its parts, and is far better illustrated than any work covering the same ground.

Mr. Cooke is responsible for the main part of the present volume, but the treatment of recent and fossil Brachiopods has been entrusted to Mr. Shipley and Mr. Reed respectively, both of whom are leading specialists in those groups. After an introductory statement of the position of mollusca in the animal kingdom, and the basis of classification into Cephalopoda, Gasteropoda, Schaphopoda, and Pelecypoda, Mr. Cooke describes the convenient grouping into Glossophora and Aglossa. The subsequent arrangement of matter is noteworthy and commendable. Not until the habits and general economy of mollusca have been fully considered are the animals systematically treated, and their geographical distribution considered. A point worth mention relates to the use of snails as an article of food. Judging from Mr. Cooke's account, it would seem that in this country snails are very rarely eaten. We have, however, seen dishes piled high with snails in the oyster bars of Bristol, and have eaten and enjoyed them there, and in other parts of the West of England. Mr. Shipley's chapter on recent Brachiopods is chiefly concerned with the anatomical structure of the animals. Indeed, little can be said about the habits and natural history of the Brachiopoda. The group owes its chief interest to the immense variety of its fossil forms throughout the whole series of geological formation, and Mr. Reed briefly reviews the chief characteristics of those genera which have the greatest geological importance. Having sketched out the lines upon which the volume has been constructed, it only remains to be said that if succeeding volumes are like this one, the Cambridge Natural History will rank as one of the finest works on natural history ever published.

Progress of Science. By J. Villin Marmery. Pp. 358. (Chapman and Hall.) 7s. 6d. Whoever is responsible for the series of puffs pasted inside the cover of the copy of this book received by us for review, whether it is the author or the publishers, should know it is in very bad taste. Surely it is for the reviewer to decide whether the book is "remarkable for accuracy," or exhibits "great exactness"; and it should be left for him to say that "the work will prove the most instructive of its kind." The least that can be said about such action is that it is calculated to do the book more harm than good. The place for the fourteen numbered paragraphs setting forth the claims of the book to favour is not inside a review copy.

Putting this matter aside, we are of opinion that the book will be found handy for reference, though it is by no

means complete or entirely accurate. We do not find any mention of the works of Airy, Buckland, Prestwich, Cayley, Andrews, Dana, Giekie, Croll, Janssen, Mallet, Sir John Franklin, Newcomb, Rowland, Angstrom, and many others, though space is given to their lesser contemporaries. On the other hand, in the chapter dealing with the progress of science among the Arabs, from the ninth to the fifteenth century, many names unfamiliar to European readers will be found. During this period the Arabs were in the van of civilization, and they really form the connecting link between the Greeks and ourselves. To quote Mr. Marmery, "They improved upon mathematical and astronomical knowledge; gave us algebra (solving even cubic equations), extended trigonometry, and thus met the needs of celestial geometry. But they left their mark for all times equally in medicine, physics and chemistry." In another chapter, the author makes a comparison between Roger Bacon and Francis Bacon, and shows pretty conclusively that the latter drew all his inspiration from his namesake. In our opinion, this is the best chapter in the book. The Elizabethan Bacon is effectually stripped of the plumes borrowed from the earlier Bacon—the man of the thirteenth century.

In a book of this kind, covering so wide a ground, mistakes are inevitable. Errors certainly occur, but we do not think they are so numerous as to render the book useless, though they necessarily detract from its value as a work of reference. The subject for wonder should not be so much the mistakes committed as (to use an Irishism) the mistakes that might have been made, but are not. Mr. Marmery essayed to accomplish a difficult task, and the result indicates that he was a trifle too ambitious. His selection of names as representatives of modern science shows clearly that his judgment of the relative importance of scientific work is frequently faulty. Specialists in all branches of natural knowledge may well address to him the question, "Who made thee a prince and a judge over us?"

BOOKS RECEIVED.

The Moon, with a map of its principal features. By Thomas Gwyn Elger, F.R.A.S. (Philip & Son.) 5s. net.

The Migration of British Birds. By Charles Dixon. Six maps. (Chapman & Hall.) 7s. 6d.

Geometrical Conics. By E. S. Macaulay, M.A. (Cambridge University Press.) 4s. 6d.

"Things New and Old": or, Stories from English History. By Arnold Forster. (Cassell & Co.) Illustrated. 1s. 6d.

Report of S. P. Langley, Secretary of the Smithsonian Institution, for the year ending June 30th, 1894.

Index to the Literature of Didymium, 1842-1893. By A. C. Langmuir, Ph.D.

Smithsonian Geographical Tables. Prepared by R. S. Woodward. (Washington Smithsonian Institution.)

The Elements of Botany. By Francis Darwin, M.A., M.B., F.R.S. (Cambridge University Press.) 6s.

The Wilsonian Theory and the Stonyhurst Drawings of Sunspots. By Rev. Walter Sidgreaves, S.J.

Crystallography: a Treatise on the Morphology of Crystals. By N. Story-Maskelyne, M.A., F.R.S. (Oxford: The Clarendon Press.) Illustrated. 12s. 6d.

THE FUNCTIONS OF THE HAIRS OF PLANTS.

By J. PENTLAND-SMITH, M.A., B.Sc.

THE merely descriptive botanist must exist in a paradise amongst the structures with whose functions we are about to concern ourselves, for their variety and beauty of form is almost endless. A consideration of their uses, however, and of their influence on the distribution of the plants which bear them, is a much more intellectual pleasure.

It must be confessed at the outset that, although in the majority of cases the biological significance of the hairs on plants is perfectly obvious, there are many instances in which it is impossible to conjecture their function.

Hairs may arise from any member of a plant—from the root, stem or leaf—and occasionally their presence may be observed in large internal spaces. In point of origin a hair is an epidermal structure—that is, it originates from a cell of the epidermis, or outer skin of the plant. The hairs of the root remain as simple prolongations of epidermal cells, but those found on other portions of the plant may develop in various ways, either remaining as single cells or becoming differentiated into two or more cells, which occasionally display a differentiation with regard to function.

The glistening hairs forming a downy covering on the leaves of certain plants owe their shiny appearance to the presence of air in their cavities. In many other cases the hairs of the leaf and stem at maturity contain protoplasm, a nucleus, and generally a large quantity of cell-sap. The root-hairs always belong to the latter category.

It would be an impossible task to compress into the limits of a short paper the many and varied functions performed by hairs, and the endless modifications of structure subservient to them. We shall content ourselves, then, with a five-fold physiological grouping of these structures, and shall give a few examples of each group.

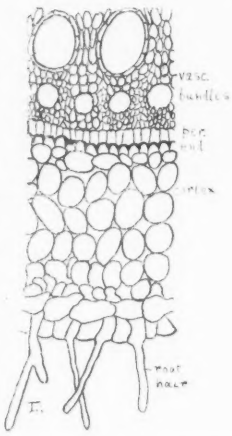


FIG. 1.—Transverse section of portion of root of Maize (*Zea mais*). *per.*, pericyle (from which young roots arise); *end.*, endodermis, or bundle-sheath; *vasc. bundles*, vascular bundles which conduct crude nutrient material from roots to leaves.

I.—Hairs may be regarded as *absorptive* organs. The hairs of this class always retain their protoplasm, nucleus, and cell-sap. The root-hairs, as we have already noted, belong to it. Carbon, hydrogen, nitrogen, oxygen, phosphorus, potassium, magnesium, calcium, and iron are the elements from which the food of a green plant is produced. It normally obtains them all from the soil (with the exception of carbon and oxygen, which it derives from the air) in the form of compounds called mineral or inorganic salts, and water. The salts must be soluble in water or dilute acids to be available for the nutrition of the plant, as it is only in this form that the roots can absorb them. In search of these they ramify through the soil. The general surface of the root does not act as an absorbent; the root-hairs alone perform this function. They contain solutions of organic acids which are denser than the solutions of inorganic salts in the soil, and a current is thus set up from the outside inwards. It passes cell by cell to the interior of the root, where it enters the vascular bundles, which carry it up the stem to the leaves (see Fig. 1). It is to be specially noted in passing that this solution is very weak—it might be compared to tap-water—as we shall have to speak by and by of the aid given by certain hairs to the process of getting rid of the excess of water.

The root-hairs by secreting organic acids help to dissolve, and so render available as food, salts insoluble in water. Roots can thus be made to trace out their course in the soil, if a polished slab of marble be placed at a suitable depth underground. It may be noted from Fig. 2, which

is a semi-diagrammatic representation of the "rhizoids" and part of the stem of a very common moss (*Funaria hygrometrica*), that particles of soil are adherent to the large rhizoids (root-hairs). As the specimen from which this was drawn was washed repeatedly in water and brushed with a camel's-hair brush, it is evident that the hairs of the plant cling firmly to the soil particles. In addition, then, to absorbing water, they fasten the plant in the soil. The attempt to clean thoroughly the roots of a maize seedling will make this obvious to the reader. To obtain a specimen of it without injury to the root-hairs, it is necessary to germinate the fruits in water or damp sawdust.

FIG. 2.—Lower portion of stem and "rhizoids" of *Funaria hygrometrica*. Notice the soil particles clinging to the hairs.

Negative evidence in support of the absorptive function of root-hairs can be obtained by the examination of the roots of a water plant, such as Potamogeton, or the aerial roots of an epiphyte, such as an orchid. In the former there is no necessity for such organs, as the whole root is surrounded by water, and in the latter there is a special modification of the cortical and epidermal cells, enabling these plants to condense and absorb the moisture of the air. In the case of a few epiphytes, however, the presence of root-hairs must be noted, but the plants bearing them grow in damp, shady situations, where there is no chance of these delicate organs being dried up.

Root-hairs are short-lived. As the roots increase in length, new root-hairs are developed at a short distance behind the growing point, and the old ones die off. The plant is thus continually brought into contact with fresh sources of food.

In higher plants the absorption of water by the stem and leaves is the exception, not the rule. The outer layers of the epidermal cells are, moreover, less impervious to water, being infiltrated with a substance called cutin, or covered with a coating of wax, which renders them quite impervious. We shall now cite a few instances in which the epidermal cells are modified into hairs that act undoubtedly as absorptive organs. One of the most curious is found in the common ash. The upper surface of the midrib of the leaf is deeply grooved, the lips of the groove meeting above except at the points of origin of the leaflets. Water falling on the leaflets runs into the tube at these points, and once entered, its evaporation is prevented. From the under surface and sides of the tube arise multicellular hairs. When the transpiration of water from the leaf exceeds the supply brought up from the roots, these hairs absorb the water in the tube. Thus there is a guard against desiccation of the leaf.

The common chickweed (*Stellaria media*) is an annual plant that abounds as a weed in cultivated places. Its native habitat is the banks of streams, and road sides. It is quite devoid of hairs excepting a ridge down one side, between the pairs of opposite leaves, as seen in Fig. 3. Long hairs are also borne on the margins of the petioles or leaf-stalks. After a shower of rain the surface of the leaves is quite dry, but the water is retained by the ridge of hairs. Let us consider more fully the action of these bodies. If the supply of water is in excess of what can be retained by the hairs of the uppermost ridge, it flows to the pair of opposite leaves situated immediately below, where a certain amount is held by the ciliate hairs of the petioles, while the superfluous supply flows down to those on the ridge below, and so on. A quantity of water thus bathes the bases of the hairs on the stem and leaves. The hairs are multicellular filaments, with nucleus, protoplasm, and cell-sap. The upper cells, according to Kerner, do not absorb water, but it passes through the basal cell-walls, and is absorbed by the protoplasm and passed on to the interior of the stem or leaf. As proof of this, he instances the fact that when the water has dried off the ridges the cell-walls of the basal cells exhibit a striated appearance, which can only be accounted for by supposing a loss of water from their interior. A good absorber is a good transpirer, unless special provisions are made to prevent transpiration. These basal cells, then, having no special protection, exhale in dry weather the water they previously absorbed in wet. It is somewhat difficult to account for the use of the extra supply of water in this case. Many plants growing by the banks of streams are likewise endowed. In damp situations it would appear at first sight that such a supply is superfluous. Perhaps Kerner's explanation, put forward for similar cases, and which seems to be the only one forthcoming, is the correct one. Nitrogen is one of the main constituents of plant food. As we have stated, a green plant normally obtains it from the soil in the form of soluble inorganic salts. This constituent of food is lacking in sufficient quantities in marshy situations, hence we find plants like Drosera (sundew) and Pinguicula (Butterwort) inhabiting these regions, endowed with capturing and digestive apparatus enabling them to obtain nitrogen from the bodies of living animals, which they retain, kill, and then digest. Certain members of the pea tribe are able to make use of the nitrogen of the air (see March and April numbers of KNOWLEDGE, 1894) as a source of food, but it has never been contended that there is any reason to suppose that other higher plants are likewise endowed. In the air, however, ammonia and nitric acid are present in very small quantities. They are carried to the soil by rain water, and it has been estimated that from four to twenty pounds of nitrogen in the form of nitric acid may be distributed annually over an acre of ground by the rainfall. May it not be the case, then, that the tiny droplets of water retained by the leaves of this plant after every shower of rain contain in the aggregate a supply of nitrogen sufficient to make up for the deficiency in the soil, which, being absorbed in the manner indicated, materially benefit the plant?

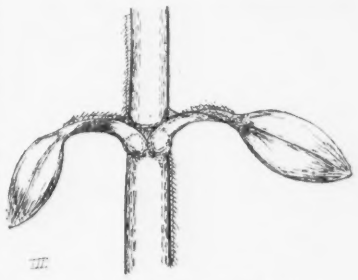


FIG. 3.—Portion of stem of *Stellaria media* (chickweed), enlarged. Notice the unilateral ridges of hairs, and the hairs on the petioles.

A very pretty contrivance for absorption and retention of water is seen on the under surface of the leaves of the Alpine rose (*Rhododendron hirsutum*). It consists of a number of multicellular hairs, each shaped like a disc, supported by a short stalk. Each hair is lodged in a depression on the under surface of the leaf, generally situated below a vein. The cells of the glandular hairs secrete a resinous matter that forms a brown incrustation on the under surface of the leaf. When rain falls on the upper surface it soon reaches the under surface, partly by

the agency of the marginal hairs. This results in the swelling up of the resinous material and the absorption of water by the glands. In dry weather the resin, drying up, encrusts the glandular hairs, and thus prevents evaporation from their surface.

Similar provisions for the absorption of water during wet weather, and its retention during dry periods, are marked in the family of the Saxifrages. In *Saxifraga aizoon*, the evergreen saxifrage, the small somewhat fleshy leaves are deeply serrated, and on the upper surface of each tooth there is a well-marked depression, whose base is lined with cells secreting carbonate of lime. The presence of this substance gives quite a greyish-white appearance to the leaf margin. The incrustation is held in its place by knobbed hairs that arise from certain of the epidermal cells. This saxifrage, in common with its allies, is found in rocky situations, where, subjected to the action of a strong sun, it stands much chance of desiccation. The incrustation of lime serves to prevent the evaporation of water, but when rain comes it soaks under the crust, and the delicate walled secreting cells can now act as absorbents. In dry weather the crust sinks down again, and plugs up the cavity; but it often happens that, even with these provisions, the leaf becomes so dried up that it curls upwards, thus cracking the lime stoppers, which would be easily blown away by a strong wind were it not that each is held in its place by the hairs whose presence we have already mentioned.

The stem and leaves of the Pelargoniums (the "Geraniums" cultivated in our glass-houses are really Pelargoniums) bear numerous unicellular and multicellular hairs. Two forms of these are represented in Fig. 4. In many cases the latter are more swollen at the tip than the specimen to the left of the figure, and they then receive the name of capitate hairs. The outer wall of the apical cell is very thick, but in wet weather it swells up and becomes converted into a resinous material, which peels off, and permits of the passage of water into the interior of the cell. The resinous matter is secreted by the cell, and is bounded on the outside by a thick layer of cuticular substance, which peels off with it. Then the cell secretes a fresh supply of resinous substance, that hardens as the weather becomes dry, and so prevents evaporation from the outer surface of the hairs.

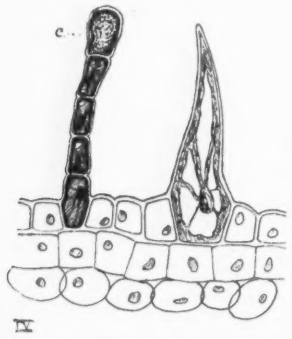


FIG. 4.—Portion of epidermis and underlying tissue of Pelargonium, with secreting hair (*c*), and a sharp-pointed hair.

II.—Hairs also function as maintainers of a free passage for the flow of water vapour from the stomata. The very dilute solution of nutrient salts absorbed by the root-hairs passes up the stem chiefly through the special conducting layers of tissue called the vascular bundles, whose terminations are the veins of the leaves. From the leaves the superfluous water is evaporated, not from the general surface, for that, as we have seen, is more or less impervious to water, but by specially modified organs called stomata (Greek στωμα, a mouth). If the evaporation of water be retarded, it stands to reason that the plant will receive less nourishment than when the process is being actively carried on. Any obstacle, then, that prevents the free transpiration of water will be detrimental to its growth. Thus, any contrivance which prevents the blocking up of the stomata, by water or other substances, will be more or less effective in promoting the development of the organism.

The leaves of *Nerium oleander* (the Oleander), a plant commonly grown in our glass-houses, and much used during summer for outdoor decoration on the Continent, have their stomata situated at the base of deep pits in the under epidermis. The entrance to these is guarded by a large number of comparatively long unicellular hairs, that arise from the sides of the cavities. A transverse section of a portion of an Oleander leaf is represented in Fig. 5; *st.* are the stomata, and *h* the hairs; *ep.* is the epidermis of the under surface. A surface view of a portion of the epidermis is shown in Fig. 6, the lettering being the same as for the previous figure. The hairs are not wetted by moisture. They prevent water which may pass to the under surface of the leaf from blocking up the stomatic orifices. As the Oleander grows in damp situations, transpiration, and consequently growth, would be retarded were there not some means of preventing the excessive moisture to which it is subjected in its native habitat (the banks of streams and similarly moist situations in Southern Europe) from blocking up the stomatic orifices by drops of water.

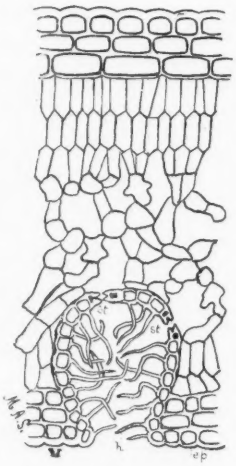


FIG. 5.—Transverse section of portion of leaf of Oleander (*Nerium oleander*), with pit on lower surface. *st.*, stomata; *h*, hairs.

This is exemplified in a still more remarkable manner by the rolled leaves of *Azalea procumbens*, and Kerner states that it is common to rolled leaves from all parts of the world. In *Azalea procumbens*, the trailing Azalea, the leaf is rolled inwards, as shown in Fig. 7. There is a marked ridge of tissue below the vascular bundle of the midrib, dividing the under surface of the leaf into two well-defined longitudinal grooves. From the under surface of the epidermal cells depend filamentous processes of the cuticle, which, perhaps, strictly speaking, we should not term true hairs, as they are solid, not hollow. This species of azalea grows in situations where the underlying soil is moist for the greater part of the year, and thus renders transpiration from the leaves a matter of difficulty. Hence it is necessary that, when bright sunny weather does make its appearance, the plant should be able to take full advantage of it. This is effectually provided for by the arrangement in question. Moisture does not wet the hair-like cuticular processes, and so the passage of water into the stomata is prevented, and a clear air space is maintained around the stomatic orifices.

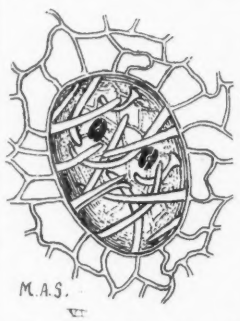


FIG. 6.—Surface view of pit, with hairs and stomata of the foregoing.

III.—A third function performed by hairs is that of protection. There are innumerable instances in which

hairs, or hair-like structures, have evidently arisen for this purpose. The ordinary Hawkweed (*Hieracium pilosella*) affords us a good example of this. It is a plant belonging to the natural order Compositæ (the daisy order), and resembles a dandelion in some respects. It is widely distributed in Britain. The under surface of its leaves is covered with hairs that have lost their protoplasmic contents, and whose cavities are filled with air. Air, as is well known, is a bad conductor of heat. The greater the heat the greater the transpiration, and conversely a decrease in temperature involves a corresponding decrease in evaporation, other conditions remaining the same. Thus the hairs of this plant form an effective screen from the solar rays, and lessen the amount of transpiration. That this is the function of these structures is fairly apparent. The ground in which the plant grows frequently dries up, and then it is found that the leaves curl upwards, and so expose their felted under surface to the sun, thus effectively lessening the chance of desiccation.

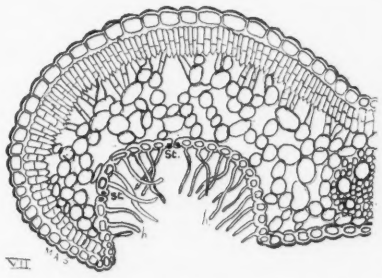


FIG. 7.—Transverse section of half of leaf of *Azalea procumbens*. *st.*, stomata; *h*, cuticular processes—"hairs" of epidermal cells.

A still better example of a plant provided with protective hairs is the Edelweiss (*Gnaphalium leontopodium*), which grows in the Alps at a height of from five thousand to six thousand feet. Its leaves appear like tufts of wool, so densely are they clothed on both surfaces with long multicellular hairs, filled with air. The cuticle of the epidermal cells is thin, and thus affords no protection to excessive transpiration. These hairs not only form an effectual safeguard in this respect, but also protect the plant in a very efficient manner from frost and cold.

The epidermis of the leaf of Eleagnus is covered with large stellate hairs, as is shown in Fig. 8, which have a similar protective function; but a more remarkable example of a plant with leaves covered with protective structures is the *Rochea* (*Saxifraga*) *falcata*, a native of South Africa. The hairs of this plant assume the form of enormously swollen bladders. The leaf is very succulent and the ordinary epidermal cells are thin-walled. The walls of these bladder-like hairs are impregnated with silica, and the bladders fit into one another so as to form a complete siliceous coat to the surface of the leaf. They thus effectually protect the desiccation of the underlying tissue. By careful focussing a distinct nucleus may be observed in some of these swollen cells, implying, of course, the presence of protoplasm and cell-sap, and showing how effectually the flinty armour performs its work. A transverse section of the epidermis from the leaf of Rochea is shown in Fig. 9.

A very effective coating of protective hairs is exhibited by the male shield fern (*Nephrodium filix-mas*). The young leaves and the upper part of the stem are densely covered by innumerable scaly hairs, sometimes termed ramenta, destitute of cell-contents. These must be especially serviceable in shielding the plants from the injurious effects that follow sudden changes of temperature, and they protect the delicate growing portion from cold and excessive moisture.

The deposition of pollen upon the stigma is called pollination, and there are many contrivances to prevent self-pollination, and also many others to ensure cross-pollination—that is, the deposition of pollen from another

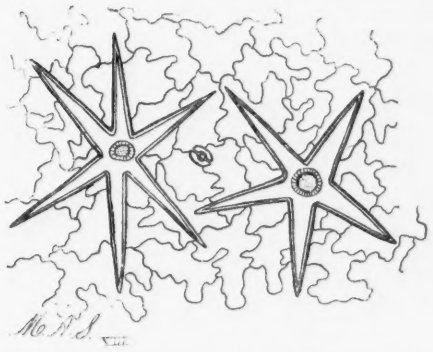


FIG. 8.—Under surface of leaf of Eleagnus, with stellate hairs.

plant (of the same species). In certain cases it has been shown that the seeds produced as the result of cross-fertilization are more numerous and superior to those resulting from self-fertilization. Cross-pollination is often effected by insects, and to attract them plants may go to the expense of secreting nectar. But the sweet juice attracts insects that are too small to effect the work of cross-pollination, as well as effective larger ones. If the former succeed in obtaining the coveted secretion, the plant will have spent its energies in vain. Means are, therefore, taken to frustrate the attempts of these small animals at visiting the flowers, and hairs are often the agents thus employed. These hairs pour forth a sticky secretion, in which the unwary insect becomes entrapped, and meets an ignominious death. As an example of this we may cite the *Silene muscipula*, or Catchfly, a very common British plant belonging to the natural order Caryophyllaceæ (the pink order), which has received its name from this circumstance. The sticky hairs are only developed on and near the floral region of the stem, and offer an effective trap for unwelcome guests.

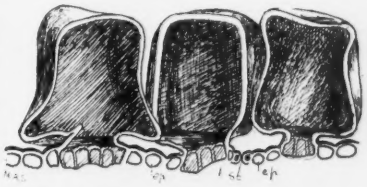


FIG. 9.—Transverse section of upper part of epidermis of *Rochea* (*Saxifraga*) *falcata*, with bladder-shaped hairs (*h*), whose walls are impregnated with silica; *ep.*, ordinary epidermal cell; *st.*, stoma.

IV.—A fourth use to which hairs are subservient is again connected with the pollination of flowers. In some cases the hairs prevent self-pollination; in other instances they are the active agents in effecting it. The Compositæ afford us very good examples of both cases. The plants belonging to this order are characterized by the possession of five stamens attached to the petals, whose filaments are free from one another, but whose anthers are united into a tube. The upper part of the style is bifurcated, but the forks are at first closely apposed, and their outer surface is covered with hairs. The inner surface of each fork is the stigmatic surface. The upper part of the style is enclosed by the anthers while the flower is young, but by and by an increase in the length of the style occurs causing the upper hairy portion to push its way through the anther tube like a bottle brush, dislodging the contained pollen

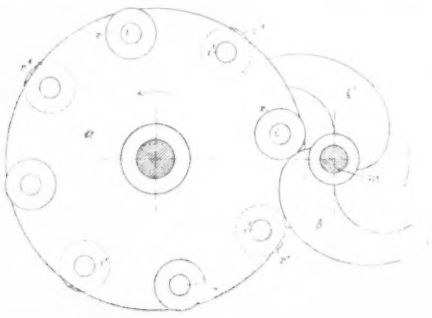
grains, which may fall on neighbouring flowers or be carried off by insects. In this way their self-pollination is prevented; but afterwards the lobes of the style turn backwards, bringing part of the stigmas into contact with some of the lower hairs on which pollen grains are still adherent. Thus self-pollination may take place if cross-pollination has not been effected.

V.—Hairs are of great use in aiding the dissemination of fruits and seeds. Everyone knows the fruit of the dandelion, with its long stalk, bearing a crown of long delicate hairs, that enable it to be wafted considerable distances by the wind. Then, again, the seeds of the Willow herb (*Epilobium*) are furnished with beautiful white hairs, which act in the same manner as those of the dandelion.

Instead of losing their cell contents like those we have cited, the hairs may remain succulent, and thus help to produce a pulpy fruit, which, attracting birds and other animals, acts indirectly in the dissemination of the seed. The orange is a good example of such a case. The pulpy portion is wholly composed of enormously long unicellular hairs.

Some Recent Patents.

Carl Hamann, Rheinbeck, Germany. Improvements in gear for transmitting rotary motion. This gearing is adapted for the transmission of great power, and comprises a rotating disc *a*, having on each side, near its periphery, rollers *r* and *r'*, turning on gudgeons *i i'*. Also a double tappet turning on a shaft *m*, the two tappets being spirally shaped and situated one on each side of the disc. The



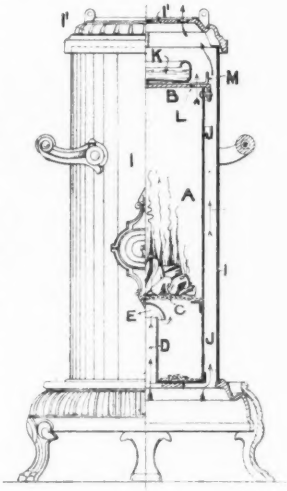
tappets are so constructed that as soon as one of them, *b*, leaves the roller *r*, which it has driven forward, the other, *b'*, on the other side of the wheel, comes into contact with the roller *r'*, and drives the latter forward. The tappets are formed to impart uniform movement to the wheel *a*.

No. 24,534. *Dated 20th December*, 1893. *Accepted 27th January*, 1894. *Three figures.*

Washington Hudson, Charlton, Kent. An improvement in clocks and watches adapted to determine the meridian. This invention consists in the addition of a third hand C, revolving once in twenty-four hours, as shown in the figure. The hour hand A is lengthened in the direction of D. B is the minute hand. At noon, when the hour hand A is at XII., the third hand C is at VI. Then, if the hour hand A is directed to the sun, the meridian hand C will point to the north, and will continue to do so at any time, whenever the hour hand A is pointed to the sun.

No. 23,219. *Dated 2nd December*, 1893. *Accepted 20th January*, 1894. *Two figures.*

John James Royle, Great Bridgewater Street, Manchester. Improvements in stoves. This invention refers to that class of stoves in which a prepared carbonaceous fuel composed of charcoal or other carbonaceous matter is burnt, the fuel being highly compressed, and burning without emitting smoke and objectionable fumes. The figure is partly in section. A is a fire box or inner casing closed with a tightly fitting lid B. C is the grate, supplied with air through a pipe D. E is a bell to keep the ashes away from the pipe D. L is an opening fitted with a regulating shutter M to regulate the rate of combustion. K is a vaporizing dish. I is the outer casing, and I' is a perforated cover. This stove may be used in ventilated rooms without any flue. The inventor has described another arrangement of stove for bed rooms, fitted with a small flue.



No. 11,207. *Dated 9th June*, 1894. *Accepted 13th April*, 1895. *Nine figures.*

THE FACE OF THE SKY FOR JUNE.

By HERBERT SADLER, F.R.A.S.

THE Sun's disc continues to be diversified by spots and faculæ, though they are decreasing.

Mercury is well situated for observation during the first half of the month. On the 1st he sets at 10h. 9m. P.M., or 2h. 5m. after the Sun, with a northern declination of 25° 18′, and an apparent diameter of 7·6″, $\frac{16}{100}$ths of the disc being illuminated. On the 6th he sets at 10h. 6m. P.M., or 1h. 57m. after the Sun, with a northern declination of 24° 23′, and an apparent diameter of 8·4″, $\frac{33}{100}$ths of the disc being illuminated. On the 11th he sets at 9h. 51m. P.M., or 1h. 38m. after the Sun, with a northern declination of 23° 9′, and an apparent diameter of 9·4″, about one quarter of the disc being illuminated. On the 16th he sets at 9h. 29m. P.M., or 1h. 13m. after the Sun, with a northern declination of 21° 46′, and an apparent diameter of 10·4″, $\frac{16}{100}$ths of the disc being illuminated. He is at his greatest eastern elongation ($23\frac{3}{4}$°) on the 5th, and in conjunction with Jupiter on the afternoon of the 8th, Mercury being $\frac{3}{4}$° to the north. While visible he describes a direct path in Gemini, without, however, approaching any conspicuous star very closely.

Venus is an evening star, and is now a resplendent object in the western sky. On the 1st she sets at 11h. 18m. P.M., or 3h. 14m. after the Sun, with a northern declination of 23° 53′, and an apparent diameter of $16\frac{1}{4}$″, $\frac{68}{100}$ths of the disc being illuminated. On the 10th she sets at 11h. 11m. P.M., or 3h. after the Sun, with a northern declination of 21° 49′, and an apparent diameter of $17\frac{1}{2}$″, $\frac{64}{100}$ths of the disc being illuminated. On the 20th she sets at 10h. 55m. P.M., or 2h. 37m. after the Sun, with a northern declination of 18° 44′, and an apparent diameter of $19\frac{1}{4}$″, $\frac{6}{10}$ths of the disc being illuminated. On the 30th she sets at 10h. 35m. P.M., or 2h. 17m. after the Sun, with a northern declination of 15° 1′, and an apparent diameter of $21\frac{1}{4}$″, $\frac{55}{100}$ths of the disc being illuminated. During the month, Venus describes a direct

path from the confines of Gemini through Cancer into Leo, passing through part of Præsepe on the 13th.

Both Mars and Jupiter have left us for the season.

The minor planet Pallas is in opposition to the Sun on the 7th, her magnitude at the present opposition being about equal to an $8\frac{1}{2}$ magnitude star. She transits on the 2nd at 0h. 41m. A.M., with a northern declination of 25° 16′; on the 14th at 11h. 44m. P.M., with a northern declination of 25° 31′; and on the 26th at 10h. 47m. P.M., with a northern declination of 25° 1′. Her path through the month is described in the constellation Hercules. She is in conjunction with the $3\frac{1}{2}$ magnitude star δ Herculis at 9h. 45m. P.M. on the 20th, $22\frac{1}{2}'$ to the north, and with the $6\frac{1}{2}$ magnitude star 62 Herculis on the 29th, 10′ to the north.

Saturn is, notwithstanding his somewhat low altitude, favourably placed for observation. He rises on the 1st at 3h. 56m. P.M., with a southern declination of 9° 28′, and an apparent equatorial diameter of $18\frac{1}{2}''$ (the major axis of the ring-system being $42\frac{1}{2}''$ in diameter, and the minor 12·0″). On the 10th he rises at 3h. 27m. P.M., with a southern declination of 9° 22′, and an apparent equatorial diameter of $18\frac{1}{2}''$ (the major axis of the ring-system being 42″ in diameter, and the minor $11\frac{3}{4}''$). On the 18th he rises at 2h. 55m. P.M., with a southern declination of 9° 19′, and an apparent equatorial diameter of 18″ (the major axis of the ring-system being $41\frac{1}{2}''$ in diameter, and the minor $11\frac{1}{2}''$). On the 30th he rises at 2h. 7m. P.M., with a southern declination of 9° 18′, and an apparent equatorial diameter of $17\frac{3}{4}''$ (the major axis of the ring-system being $40\frac{3}{4}''$ in diameter, and the minor $11\frac{1}{3}''$). Titan is at his greatest eastern elongations at 11h. A.M. on the 2nd and $10\frac{1}{2}$h. A.M. on the 18th; and Iapetus at his greatest western elongation on the 20th. During June, Saturn describes a short retrograde path in Virgo, without approaching any naked-eye star very closely.

Uranus is an evening star, and but for his great southern declination would be well placed for observation. He rises on the 1st at 5h. 41m. P.M., with a southern declination of 16° 45′, and an apparent diameter of 3·8″. On the 30th he rises at 3h. 42m. P.M., with a southern declination of 16° 21′. During June he describes a short retrograde path in Libra, without approaching any naked-eye star.

Neptune is in conjunction with the Sun on the 6th.

There are no well-marked showers of shooting stars in June.

The Moon is full at 11h. 0m. A.M. on the 7th; enters her last quarter at 11h. 28m. P.M. on the 15th; is new at 9h. 51m. P.M. on the 22nd; and enters her last quarter at 2h. 1m. P.M. on the 29th. She is in apogee at 3h. P.M. on the 13th (distance from the earth 251,320 miles); and in perigee at noon on the 5th (distance from the earth 225,260 miles). At 8h. 46m. P.M. on the 2nd the 5th magnitude star ψ Virginis will make a near approach to the lunar limb at an angle of 217°. At 10h. 44m. P.M. on the 6th the $3\frac{1}{2}$ magnitude star τ Scorpii will disappear at an angle of 185°, and reappear at 10h. 59m. P.M. at an angle of 206°. At 10h. 44m. P.M. on the 9th the 6th magnitude star B.A.C. 6666 will disappear at an angle of 63°, the star rising at the time, and disappear at 11h. 56m. P.M. at an angle of 283°. At 10h. 47m. P.M. on the 25th the 6th magnitude star 83 Cancri will make a near approach to the lunar limb at an angle of 23°. At 8h. 4m. P.M. on the 26th the $1\frac{1}{2}$ magnitude star α Leonis (Regulus) will disappear at an angle of 147°, the Sun being above the horizon at the time, and reappear at 8h. 56m. P.M. at an angle of 275°. At 8h. 8m. P.M. on the 29th the 6th magnitude star 28 Virginis will make a near approach to the lunar limb at an angle of 34°, the Sun being above the horizon at the time.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of May Problem.

(N. Alliston.)

Key move.—1. P to QB4.

Followed by 2. Kt to B5.

CORRECT SOLUTIONS received from Alpha, W. Willby, H. S. Brandreth, J. T. Reeve, J. T. Blakemore, E. W. Brook, W. O. Brigstocke, F. G. Ackerley, F. V. Louis, W. W. Strickland, A. Louis, C. W. Greenwood.

F. V. Louis.—Two out of the four mates are pure.

J. T. Blakemore.—Shall be glad to receive a three-move problem from you.

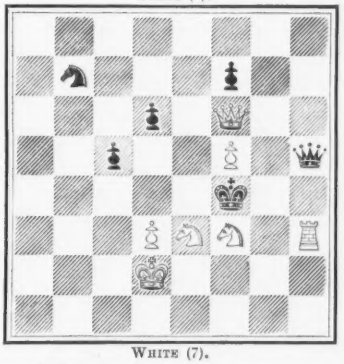
W. Willby.—Your criticism is just.

PROBLEMS.

By A. C. CHALLENGER.

No. 1.

BLACK (6).

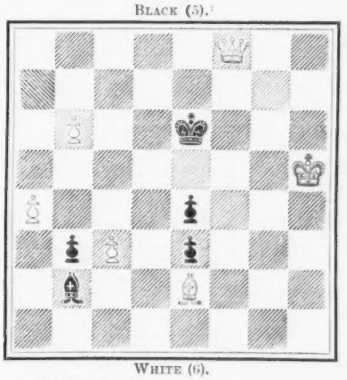


WHITE (7).

White mates in two moves.

No. 2.

BLACK (5).



WHITE (6).

White mates in three moves.

XUM

CHESS INTELLIGENCE.

The semi-final round in the Southern Counties competition has now been completed. On May 8th Sussex beat Northamptonshire, without much difficulty, by ten games to five. In the other division Gloucestershire played Wiltshire; the result depends on the adjudication of half a dozen games, but it is practically certain that Gloucestershire will be left in to contest the final tie with Sussex in June.

The correspondence match between Paris and St. Petersburg resulted in a draw. Paris won the close game, in which they had the move; while St. Petersburg succeeded in winning what should have been a drawn ending, the result of an Evans Gambit.

Mr. D. Y. Mills has again won the championship of Scotland. It is stated that he intends to assist Gloucestershire in their match with Sussex this month. This energy should be an example to the latter county.

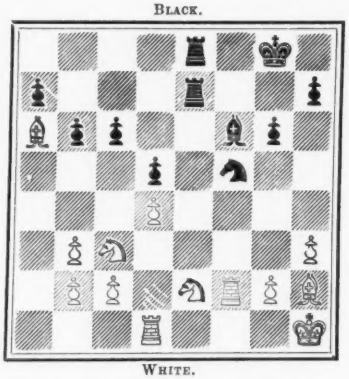
The award in the *Chess-Monthly* Problem Tournament is at length published. Of the English composers, Messrs. B. G. Laws and G. Hume were the most successful, the former winning the first prize in the four-move section, and being placed in both the other direct-mate sections, while Mr. Hume won the first prize both for three-move and four-move sui-mates.

Herr von Bardeleben, of Berlin, began a match of five games up with Mr. Blackburne on April 25th at the British Chess Club. Progress has been rather slow, and the games of some length, the present score being Blackburne, three; Bardeleben, two; drawn, two. The English player is, perhaps, not equal to his opponent in book knowledge, but atones for the deficiency by superior ingenuity and unrivalled skill in the end-game. We give below the opening game of the match. The conductor of the Black forces is easily recognized as Mr. Blackburne by the unusually late development of the Queen's Bishop, and by the playing of the King's Bishop to K2.

"Vienna Opening."

Bardeleben. WHITE.	Blackburne. BLACK.
1. P to K4	1. P to K4
2. Kt to QB3	2. Kt to KB3
3. B to B4	3. Kt to B3
4. P to Q3	4. P to Q3
5. KKt to K2	5. B to K2
6. Castles	6. Castles
7. P to B4	7. P × P
8. B × P	8. Kt to QR4
9. B to QKt3	9. Kt × B
10. RP × Kt	10. P to B3
11. P to R3	11. P to Q4
12. P to K5	12. Kt to R4
13. B to R2	13. P to KKt3
14. P to Q4	14. Kt to Kt2
15. Q to Q2	15. Kt to K3
16. QR to Qsq	16. P to Kt3
17. K to Rsq	17. B to R3
18. R to KKtsq	18. B to KKt4
19. Q to Ksq	19. P to KB4
20. P × Pep	20. Q × P
21. Q to Kt3	21. Kt to Kt2
22. Q to B7	22. R to B2
23. KR to Bsq	23. Kt to B4
24. Q to K5	24. R to K2
25. Q × Q	25. B × Q
26. R to B2	26. QR to Ksq

BLACK.



WHITE.

27. R to Rsq	27. B × Kt
28. P to KKt4	28. B × QP
29. R × B	29. B × Kt
30. R × R	30. R × R
31. P × B	31. Kt to Kt2
32. P to Kt4	32. Kt to Ksq
33. R to Qsq	33. Kt to B3
34. B to Kt8	34. Kt to K5
35. R to Rsq	35. Kt × P
36. R × P	36. R × R
37. B × R	37. P to QKt4 and wins

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